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ORIGINAL ARTICLES.

Contributions to the Geology of Cyprus.

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PART II.

The Tertiary Formations.

THE Tertiary beds cover the greater part of the island of Cyprus and their general distribution is shown in Bellamy's map published in 1905, while their characters and relations have been described with a certain amount of detail in Bellamy and Jukes-Browne's memoir on *The Geology of Cyprus* (1).[1] Since then Philippson (37) has given a useful summary of our knowledge of the geology of the island with references to the literature up to the year 1918, and Cullis and Edge (38), though principally concerned with the igneous rocks, have more recently published a revised map with a summary of the Tertiary beds. But much work is still required before an adequate knowledge of them is obtained. The division into Eocene (Lapithos beds), Kythrean (Oligocene ?), Idalian (Miocene) and Pliocene + Pleistocene Series as adopted in Bellamy's memoir, is convenient for a rough local classification of the beds. But the grouping of the Pliocene with the Pleistocene was obviously done owing to insufficient knowledge, and further subdivision of the series is undoubtedly necessary. Bellamy followed Gaudry (3) in regarding the Pliocene beds of the Carpas as representing an older stage than those of the central and southern districts. Russell (2) had previously recognized a lower series in the central valley which he called the Nicosia beds containing very abundant fossils, and an upper series which he termed the Kerynia Rock, comprising a yellow calcareous sandstone which furnishes most of the building stone in the island.

The Pleistocene formations which are very varied in character do not come within the scope of the present paper, though in some cases the distinction between Pliocene and Pleistocene marine deposits is difficult to fix. The Idalian Series has mainly a calcareous facies and though largely unfossiliferous has yielded sufficient fossils in the past to indicate a Miocene (Helvetian) age, at any rate for some part of it. The underlying Kythrean has been doubtfully ascribed to the Upper Eocene or Oligocene, but the determination of its age was not one of the questions which the author set out to solve. The older Lapithos beds (1), (14*a*) were also outside the scope of his work on this visit, his chief aim being to collect sufficient material from the fossiliferous Miocene and Pliocene deposits in the island, so as to establish a closer correlation with the beds of other countries bordering the Mediterranean, especially with those of Asia Minor. The complete examination of the whole island was rendered impossible owing to bad weather conditions and other adverse circumstances, but sufficient evidence was obtained to prove that several stages in the Miocene and Pliocene are represented and that there is a remarkable faunistic resemblance to the corresponding deposits in Italy.[1] No trace has so far been found of the widespread Pliocene freshwater and brackish deposits of Asia Minor, Syria, Palestine and Egypt, only marine beds of this age being known in Cyprus.

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[1] Figures in parentheses refer to References at end.

As the present author has pointed out in his previous paper (4) it is abundantly confirmed that the structural relations of Cyprus are with Asia Minor, and the whole development of the rocks and character of the formations are more like those of the region on the mainland north of the Afrin line, as Kober (36) and Krenkel (5, p. 120) have demonstrated, than those to the south of this line in Palestine and Egypt. But it may be mentioned that the gypseous deposits occurring at the base of the Idalian Series correspond in general position with those of Egypt, the Red Sea, Persia and Iraq, indicating that similar conditions were widespread at this period (35, p. 298). The association of oil-bearing strata with these beds in the countries mentioned has led to borings for the same purpose in Cyprus, though so far they have proved unprofitable or fruitless (29).

Blanckenhorn (6, p. 49) maintained that Cyprus together with northern Egypt, Cilicia, Armenia and Persia was covered by the sea in Oligocene times while Syria-Arabia formed a continental mass. According to him the Kythrean beds in Cyprus would seem to be probably referable to the Oligocene, and the submergence to have lasted on through part or most of Miocene times during which the Idalian Series was being formed. Elevation at the end of the Miocene then took place, uniting Cyprus with the mainland, and it has been generally considered that no fresh submergence occurred till the Middle or Upper Pliocene. But this latter conclusion requires qualification in consequence of the author's recent work, as will appear below.

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[1] The large collection of Pliocene fossils from Italy in the Sedgwick Museum has proved of invaluable assistance for purposes of identification and comparison.

In spite of local submergence in Pliocene times leading to the deposition of marine beds in Cyprus, Crete, Rhodes and elsewhere in this region Frech (12, p. 319) believes that it was not till the close of the Tertiary period that the general break-up of the land-masses in these parts took place and that the straits between Cyprus and the neighbouring mainland were formed. These movements are believed to have lasted on into the youngest Quaternary. But it is certain that they were accompanied by considerable elevation, and Russell (2) appears to have been approximately correct in maintaining that this elevation which occurred during this post-Pliocene period reached an amount of 1,800–2,000 feet, for some of the fossiliferous marine Pliocene deposits in the island have been found by the author at heights of more than 1,000 feet and Bergeat (14, p. 278) mentions Pliocene oyster beds between Nicosia and Nisu at a height of 280 metres, while on the mainland in the Palmyra desert the marine Pliocene is stated (36) to occur at a height of about 650 metres.

Bellamy (1, pp. 53–6) was of the opinion that the continental conditions during which Cyprus was united with the mainland on the north and on the east lasted well into the Pliocene, and that consequently none of the Pliocene marine fossils in the island indicate a more ancient epoch than the Astian of Italy or our Red Crag. We cannot, however, agree with this contention, for it will be shown that a fauna of Plaisancian type certainly exists in some of the deposits in Cyprus, and it should be remembered that such has been previously recorded in Crete (16) which belongs to the same structural province and was probably affected by the same earth-movements.

Lapithos Beds.—It has been suggested by the author (4, pp. 442 *et seq.*) that the crushed shaly limestones in the Panagra Gorge and elsewhere (1, pp. 11–14) in contact with the older igneous rocks probably belong to this series, but no nummulites or other fossils such as Bergeat (14) and Simonelli (14*a*) mentioned were found in them. Further search is desirable.

Kythrean Series.—The Kythrean beds which are mainly greenish sandstones and flags have previously only yielded tests of *Globigerina*, according to Bellamy (1, pp. 21, 69); otherwise there is stated to be an entire absence of any fossil remains. It was therefore of interest to discover on the road to Kyrenia about 6½ miles from Nicosia some layers of thinly bedded tough greenish or rusty flags 3 to 4 inches in thickness intercalated amongst the soft green massive sandstones, dipping north at 60°–75°, which yielded fucoid markings, worm-tracks and abundant pteropods, though the latter were mostly badly preserved. We can however, recognize as the most abundant form members of the genus *Balantium* (cf. *B. pedemontana* May.),[1] and it is probable that the genera *Vaginella* and *Hyalaea* are also represented.

It is probable that the same fossiliferous beds will be found in other localities in the island, but the author had no opportunity of looking for them. The Flysch-like character of the Kythrean suggests the older Tertiaries of the Tauric marginal chains in which this lithological type is conspicuously developed (5), (11), (36), but it is stated to be absent south of the Afrin line on the mainland. Kober (36) correlates the Kythrean Series definitely with the Oligocene.

Idalian Series.—The Idalian Series of beds consists of three fairly well-marked stages: the lowest is composed of greyish and greenish marls with occasional beds of gypsum and seems to rest conformably on the Kythrean Series; the middle stage is the thickest and most conspicuous in the island, consisting of white chalks and marls with layers or nodules of flint or chert in places, and it is from these beds that most of the fossils have been obtained; the upper stage is composed of hard shelly limestones, white or tinted, but some of them may be of Pliocene age (29, p. 628) for in some places there does not seem to be any break in the succession, e.g. the Karpas (according to Gaudry (3) and Cullis (38) and near Curium in the south.

The lowest stage has only yielded foraminifera. The limestone at Cape Pyla (8, 1, p. 27) described by Miss Bate as containing *Clypeaster portentosus* (a variety of *Cl. altus* of Helvetian or Tortonian age) and also many marine shells and corals (of which no description has been published) is of rather doubtful position in the series as it has not been discovered elsewhere in the island, but the Miocene age of the whole Idalian Series does not appear to be open to dispute. Gaudry (3) had previously recorded *Astraea Guettardi* Defr. from the neighbourhood of Cape Greco,[2] also *Toxobrissus* [*Brissopsis*] *crescentinus* Wr. and *Chenopus pesgraculi* from Phinicaria N.E. of Limassol, a *Lucina* from Leonarisso and small spines of *Cidaris* from Neta in the Carpas. According to Bellamy (1) near Paralimni a tooth of *Carcharodon megalodon* has been found, and in a road cutting between Pachna (Pakhna) and Kissousa north of Limassol he mentions (1, p. 23) that *Aturia Aturi* Bast. and *Xenophora* (*Tugurium*) aff. *postextensum* Sacco, were discovered.

The last-mentioned locality apparently corresponds with the one visited by the author and here described (see below, *Locality* (1)). *Aturia Aturi* is, as Bellamy remarks, one of the most characteristic of the Mediterranean Miocene fossils, being typical of the Schlier

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[1] Kittl, *Ann. Nat. Hist. Mus. Wien*, i, 1886, p. 64, t. ii, figs. 28, 33.

[2] This species is recorded by Fischer (Tchihatcheff, *Asie Mineure*, pt. iv, "Paléont.," 1866, p. 312) from the Middle Tertiary of Cilicia and Crete. Kühn, in his recent description of Miocene corals from Cilicia (*Jahrb. k. k. geol. Reichsanst.*, Bd. lxxvi, 1926, pp. 65–80), mentions it, and Blanckenhorn (18, p. 326) describes it from the neighbourhood of Aleppo.

(Langhian) of the Vienna basin and of the beds correlated with it in southern Europe. In several parts of the island the author has been able to find an associated small fauna in the beds which contain *Aturia Aturi*, and this fauna much resembles that found in the Miocene of Umbria[1] and the Apennines,[2] most of the few species being identical. The presence of higher Miocene beds is indicated by fossils collected in some other localities. But most of the white limestones, chalks and marls are unfossiliferous, except for occasional foraminifera and *Lithothamnium*. It is to the Miocene of the neighbouring Asiatic coast that we should naturally look in any comparison of the Miocene of Cyprus, and it is worth noting that Bergeat (14, p. 276) states that there is complete lithological identity between the Idalian limestones and the Miocene of north Syria. Stefani (35, p. 251) considers that they are probably of Langhian age.

The recent work of Blanckenhorn (9), Daus (10), Schaffer (11, 11*a*), Koert (7), and Oppenheim (17), (18) as well as the earlier researches of Fuchs (23), Tietze (28) and others have furnished us with much information about the Miocene faunas of Cilicia, Syria and the adjoining regions in Asia Minor. The echinoid *Clypeaster altus* is now known from the basin of Aleppo (10) and Lycia (18, p. 71), and the common Idalian fossil *Liostrea cochlear* from the Orontes valley and elsewhere in northern Syria (9); the occurrence of *Aturia Aturi* in Cilicia, Lycia and in the basin of Aleppo has been recorded by Fuchs (23) and others.

The general scarcity of fossils (apart from foraminifera) in the Miocene of Cyprus is remarkable, but we have been able to add several to the previously scanty list, and it is likely that more prolonged and extensive search would furnish many more.

Dr. W. A. Macfadyen has kindly given me leave to refer to his unpublished thesis for the degree of Ph.D. which deals with the correlation of the Miocene successions of Vienna, Transylvania, Malta, Cyprus and Egypt, in which he says that "it would appear possible that the whole of the Idalian and Kythrean Series may in fact be Miocene", judging from the analogy of the successions in the other countries mentioned, and that "it seems clearly established that the Tertiary succession [in Cyprus] contains Miocene strata comparable to the Egyptian Miocene, but of rather different facies". But the list of foraminifera given by Millett in his Appendix III to Bellamy and Jukes-Browne's paper (1, pp. 71, 72) as Pliocene is stated by Dr. Macfadyen to indicate a fauna bearing a strong resemblance to that of the Egyptian Miocene, ninety-two species being common to both, while it is unlike that of the Pliocene of Rhodes. Incidentally this seems to confirm my relegation of some of the beds to the Lower Pliocene, if not to the Miocene.

[1] Verri and D'Ossat, "Mioc. Umbria," *Boll. Soc. Geol. Ital.*, xix, 1900, pp. 240–79.

[2] Nelli, "Foss. Mioc. Appennino Aquilano," ibid., xix, 1900, pp. 381–418.

In his correlation of the Miocene beds of the five areas he would recognize representatives of the Tortonian, Helvetian, Schlier and Burdigalian in the Idalian and Kythrean Series, the basal part of the latter having a flint breccia and conglomerate being doubtfully considered as also of Miocene age and as marking the unconformity with the Eocene [Lapithos beds] as in Egypt.

We can go so far at present as to state that his views as to the Miocene beds in Cyprus (apart from the Burdigalian) appear to be corroborated by the evidence now available.

The Miocene of Crete and of the island of Kasos[1] near Crete, of which we know only a little, seems specially worthy of comparison with that of Cyprus, and Bukowski records from the Miocene beds on that island the common Cyprus fossil *Liostrea cochlear.*

Description of Sections and Exposures of Idalian Beds.

Locality (1).

One of the best sections which the author visited in the island occurs in the road-cutting up the hill to Pakhna off the main road which runs north-west from Episkopi, and the following succession (in descending order) was traced from the top of the hill :—

(*a*)	Tough, white chalky limestones 6 in.–1 ft. in thickness containing oysters and *Aturia aturi* alternating with layers 1–1½ ft. in thickness of soft buff sandy shales	25 ft.
(*b*)	Sandy shales with small concretions . . .	3–4 ft.
(*c*)	Soft arenaceous white marls	4 ft.
(*d*)	Buff shaly sandstones alternating with hard white limestones	10 ft.
(*e*)	Greenish marl	6 inches
(*f*)	Tough white limestone	1 ft. 6 in.
(*g*)	Greenish marls and shales	3 ft.
(*h*)	Hard white limestones 1–2 ft. thick with interbedded layers of soft marl	15 ft.
(*i*)	Hard marl	4 ft.
(*j*)	Limestones 3 in.–1 ft. thick alternating with soft buff sandstones 6 in. thick	12 ft.
(*k*)	Tough white limestones with large oysters . .	4 ft.
(*l*)	Soft white marly limestone	2 ft.
(*m*)	Shaly buff marl 1 ft. thick passing down into greenish marl 2½ ft., with hard limestone below, all containing *Aturia* and oysters . . .	10 ft.
(*n*)	Hard thick limestone beds with thin 6 in. bands of shales containing tubular concretions . .	8 ft.
(*o*)	Shales and marls	1½ ft.
(*p*)	Light buff sandstone	2 ft.
(*q*)	Tough pale calcareous sandstone . . .	1½ ft.
(*r*)	Shales	4 ft.
(*s*)	White limestone	1 ft.
(*t*)	Shales	4 ft.

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[1] Bukowski, *Sitzungsber. K. K. Akad. Wiss. Wien* (*Math. Nat. Kld.*), B, xcviii, Abt. 1, Heft vi, 1889, pp. 653–69.

(*u*)	Buff and greenish shales containing fish scales	12 ft.
(*v*)	Flaggy white marls	5–6 ft.
(*w*)	Soft dark green shales and mudstones containing fish remains	2–3 ft.
(*x*)	Flaggy white limestones	+10 ft.

It was apparently from this exposure that the example of *Aturia Aturi* to which Bellamy refers (1, p. 23) was obtained. This series of beds resembles that in the neighbouring valley leading to Yerasa (see *Locality* (2)).

The tough white chalky limestone (bed (*a*)) in the above succession yielded the following fossils :—

Liostrea (*Pycnodonta*) *cochlear* Poli.
Nucula sp.
Lucina (*Here*) cf. *miobarbieri* Sacco ?
Capulus hungaricus L.
,, sp.
Aturia Aturi Bast.

The oysters and *Aturia Aturi* were not at all common, while only a single example of all the other species was obtained after a long search. Bed (*m*) only yielded the species of oyster and *Aturia.* All these species point to the Langhian or Helvetian age of the beds of the Second Mediterranean Stage (Vindobonian of Deperet). The fish-bearing shales occur in the lower part of the succession and are of a completely different lithological character to the mass of the formation.[1] No other fossils (except obscure plant remains) occur in them. Professor T. D. A. Cockerell of Boulder, Colorado, has been unable to detect any insects, though their presence was suspected.

Locality (2).

On the road to Yerasa about 10 miles north of Limassol there is a very fine series of exposures of the Idalian beds in the cuttings and banks. They consist of very tough compact limestones, mostly without a trace of any organic remains, and have intercalated bands of dark brownish or greenish shale or marl ; the whole series of beds dip in regular succession at about 20° to the south, with some minor undulations. In one of these limestones *Aturia Aturi* occurs, associated with pteropods (*Vaginella* sp.) and from another bed rather lower in the succession two specimens of a small poorly-preserved echinoid (? *Neopneustes* sp.) were obtained. One broken example of a large echinoid was collected which is a new species of *Heterobrissus* according to Dr. Ethel Currie, who has kindly examined it (apparently allied to *Heterobrissus Montesii* Manz. and Mazz.[2] and to *H. Formai* Airaghi). The brownish shales which constitute thin bands, are usually about 6 inches thick, and are interbedded with the limestones, but only yielded recognizable fish-scales. About

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[1] We may draw attention to the similar occurrence of brownish shales containing fish-scales which accompany the Miocene gypsiferous formation and Globigerina marls with *Aturia Aturi* at Gebel Sêt on the west side of the Red Sea (39, p. 120).

[2] Stefanini, *Palaeont. Ital.*, xiv, 1908, p. 95, t. xiv, figs. 4, 5, t. xv, fig. 1.

10 feet below the lowest band of shale a hard limestone 3 feet thick yielded specimens of *Aturia Aturi.*

The rest of the limestones exposed in the cliffs along the river nearer Yerasa did not yield a single fossil except one specimen of *Aturia* about 500 yards beyond the bridge. The beds are gently folded and faulted in places, and just beyond and opposite the village of Yerasa are in contact with the igneous rocks, the lowest beds being greyish green marls and flaggy calcareous sandstones with a thin conglomerate at the base composed of rounded and subangular pebbles derived from the igneous rocks (4, p. 445). The marls become nodular and whiter further from the contact and near the river are much crushed and shattered and show slickensided surfaces.

Locality (3).

On the road from Limassol to Paphos about 1 mile beyond the ruins of the Temple of Apollo there is a layer of soft greyish to white chalky marl near the base of the hill, only 4–6 inches in thickness, which yielded the following fossils :—

Liostrea (*Pycnodonta*) *cochlear* Poli.
Pecten ziziniae Blanck. var.[1]
Amussium (*Variamussium*) *felsineum* For.
Arca cf. *Darwini* May.
Yoldia cf. *nitida* Br.
Cardium (*Laevicardium*) *cyprium* Br.
Lucina sp.
Cerithium aff. *obsoletum* Rov.

It is probable that this marl is Tortonian in age, for conformably underlying it as far on as the bridge on the same road (*Locality* 3*a*) there are similar soft greyish or white marly chalk beds containing the following fossils which indicate a Langhian or Helvetian age :—

Pecten (*Pseudamussium*) *denudatus* Reuss.
Pecten (*Amussiopecten*) cf. *burdigalensis*, L.
Dentalium cf. *vitreum* Schröt.
Indet. gastropod.

Locality (4).

On the road from Paphos to Polis there is a fine succession of exposures of Idalian beds, mostly white chalky limestones and marls, but rarely yielding any fossils. One thin bed of greyish chalk occurs in the road-cutting just before reaching the village of Tsada from which *Liostrea* (*Pycnodonta*) *cochlear* was obtained, and the same fossil occurs on the hill over the col beyond Tsada and has a shaly bed a few feet above it which has yielded fish-scales and other obscure remains. Further along the same road (*Locality* 4*a*) between the mileposts marked 87 and 86 from Nicosia massive greyish white chalk yielded specimens of *Liostrea* (*Pycn.*) *cochlear* and one example of the shell *Pholadomya vaticana* Ponzi, var. *Fuchsi* Schaff. which (according to Sacco) ranges from the Aquitanian to the Plaisancian inclusive. But it is a typical Miocene form.[1] The fish-scale beds are also met with further on along the same road (*Locality* 4*b*) beyond the village of Stroumbi about 100 yards from the milepost 77 from Nicosia, where are greyish Idalian chalky marls with interbedded shaly and sandy layers which contain fragmentary fish-scales, but no other fossils.

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[1] Blanckenhorn, *Neues Jahrb. f. Miner.*, Beil. Bd. xvii, 1903, p. 167, t. xiii, xiv, figs. 1–7.

Locality (5).

On the road from Colossi to Triniklini there are vertical cliffs of Idalian beds rising to a height of 150–200 feet above the road which runs close to the river in the valley of the Khalasa, and just before crossing the bridge between the 11th and 12th mile from Limassol the section shows alternating hard and soft white or grey marly limestones, sandstones and shales. The limestones yielded some small lamellibranchs, and in the shales were traces of fish-scales.

The fossils are not abundant but comprise the following species, all of which are very small specimens, except the *Liostrea cochlear* :—

Liostrea (*Pycnodonta*) *cochlear* Poli.
Amussium anconitanum For. var. *prodalli* Sacco.[2]
Pecten aff. *Macphersoni* Berg.[3]
Pectunculus sp.
Leda (*Ledina*) cf. *sublaevis* Bell.
,, (*Jupiteria*) *Brocchii* Bell.
Tyndaria aff. *arata* Bell.
Cardium ? sp.
Venus cf. *Basteroti* Desh.
,, sp.
Syndesmya longicallus Scacchi ?
Turritella sp.
Vaginella sp.
Cuvieria ? sp.
Carinaria cf. *Hugardi* Bell.

This fauna points to the Helvetian or Tortonian.

Locality (5*a*).

On the north side of the Zygos River where the road from Colossi ascends the hill about a mile from the bridge we find hard, thin, flaggy beds of white limestone exposed in the road-cuttings and river bed. These yielded several specimens (unfortunately imperfect) of a large Echinoid which seems much like *Brissolampas* [*Paleopneustes*] *conicus* (Dames) [4] of the Aquitanian, but Dr. Ethel Currie says that the genus is more probably *Heterobrissus*.

Locality (6).

There is a remarkably fine series of sections of the Idalian beds in the irregular amphitheatre south of and above Pera ; a deep, irregular main gully with several subsidiary narrow ones gives many exposures and on the lower slopes the bare outcrops of the beds can be easily examined between the terraces of vines. The limestones and white chalks are regularly bedded and dip at about 30° to the north. Interbedded amongst them are about twelve thin layers of soft brown shales averaging 6 inches in thickness and about 2–4 feet apart. At the base of this alternating series of shales and chalks is a thin band full of limonite nodules. The shales were found to contain fish-scales and supposed insect remains, but Professor Cockerell was unable to recognize any. The chalks contain foraminifera, but no trace of organisms of any other kind was discovered.

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[1] Nelli, *Boll. Soc. Geol. Ital.*, vol. xix, 1900, p. 409, t. iv, figs. 7*a*, *b*.

[2] Verri and D'Ossat, "Mioc. Umbria," *Boll. Soc. Geol. Ital.*, xix, 1900, p. 264, and references.

[3] Ugolini, *Palaeont. Ital.*, xiv, 1908, p. 207, t. xxiv, fig. 13.

[4] Dames, *Palaeontographica*, xxv, 1877, p. 47, t. viii, fig. 1*a–c*.

Locality (7).

About one mile from the spot where the village road to Mamonia turns off the main road from Paphos to Limassol we meet with hard, unfossiliferous chalks and fissile limestones with some calcareous flags containing traces of fish-scales. All these beds are gently folded.

Locality (8).

It may be mentioned that at many places elsewhere in the island there are similar Idalian shales and flags which from their lithological characters may be expected to yield similar organic remains. Such are those just below the village of Leonarisso where associated with the grey Idalian Globigerina marls are shaly beds which would probably reward further search.

Locality (9).

It is unnecessary to refer to the frequent occurrence of *Globigerina* and other foraminifera in the Idalian chalks and marls except where they are extremely abundant. Such is the case in the last-mentioned locality and at Ayios Symeou near milepost 59¼ from Nicosia, where their presence can generally be detected in nearly every exposure, and probably many genera of foraminifera would reward a minute investigation of the rocks.

Locality (10).

On the road from Limassol to Paphos at the base of the cliffs below Curium there are some very fossiliferous tough carious white shelly limestones full of casts and impressions of lamellibranchs, but the fossils are difficult to extract whole and to determine. The following species can, however, be identified :—

Arca (*Pectinatarca*) cf. *pectinata* Br.
,, (*Anadara*) sp. nov. (aff. *Darwini* *May.*)
Arca (*Barbatia*) *barbata* L. var.
Pectunculus sp.
Pectunculina anomala Eichw.
Cardium (*Papillicardium*) *pertransversum* Sacco.
Cardium (*Plagiocardium*) *hirsutum* Brn.
Cardium sp.
Poromya tauromagna Sacco ?
Venus (*Chamelaea*) cf. *Philippii* May.
Venus (*Timoclea*) *ovata* Penn. var.
Mactra sp.
Corbula sp.
Lucina (*Linga*) *columbella* Lam.
,, (*Dentilucina*) *Meneghini* De Stef ?
Lucina (*Dentilucina*) *tumida* Micht. ?
,, (,,) sp.
,, (*Myrtea*) *spinifera* Montg.
Megaxinus cf. *deperditus* Micht.
Tellina sp.
Indet. gasteropods.

It is probable that these beds belong to the top of the Idalian, for they have the shelly character described by Bellamy and others as marking the highest division of this series. The fauna also has more Miocene than Pliocene affinities.

Locality (11).

A short distance west of Curium on the same road from Limassol to Paphos there occur by the roadside dipping west at 15°–20° soft greyish or white chalky beds full of *Globigerina* and containing also a few badly preserved other fossils, amongst which the following can be recognized :—

Argiope (*Megathyris*) cf. *detruncata* Ag.[1]
Arca cf. *umbonaria* May.
Megaxinus cf. *transversus* Br.

Overlying these beds are rather soft calcareous sandstones from which only one poor specimen comparable to *Venus Aglaurae* Brong. was obtained.

Further along the road close to the Temple of Apollo (*Locality* 11*a*) are tough white shelly limestones, lithologically similar in character to those already described below Curium at Locality 10. They yielded some poorly preserved fossils amongst which are casts of indeterminable gasteropods, *Lucina* (*Dentilucina*) *Meneghini* De Stef. ? and a species of *Cardium*. Probably all these beds belong to the top of the Idalian Series.

Locality (12).

The Koronia Limestone (? Miocene).—A short distance before reaching milepost 26 on the road from Nicosia to Evrykou we find magnesian and silicified limestones occurring in massive beds on both sides of the road and resting quite unconformably on pillow lavas with a conglomerate 3–4 feet thick at the base. Bellamy (1, p. 30), in referring apparently to the same exposures, stated that no clear exposure of the limestone in contact with the igneous rock had been observed here. The exposure, however, which now exists is very clear, and the conglomerate consists of a calcareous matrix containing rolled fragments of the pillow lavas and of other igneous rocks. This limestone has been termed the Koronia Limestone (1, p. 29) and its age has been disputed owing to the absence of any fossil evidence. We found that while the northern slopes of the hill which here rises to the west of the road consist mainly of massive or marly magnesian limestone with occasional abundance of foraminifera (*Globigerina*) the lower part of the limestone is concretionary and near its base at road level is silicified, very tough, and full of casts of small indeterminable gasteropods. Fortunately, in one spot by the roadside some well-preserved and sharp impressions of more than one gasteropod were found, and it is possible to recognize at least two species,

[1] Gaudry records *Argiope detruncata* from the Older Pliocene of the Carpas.

one of which is much like *Cerithium procrenatum* var. *pseudoacrenata* Sacco [1] and the other is an allied species with fewer but more marked longitudinal costae. The former is a Helvetian species, so that it is probable that this limestone is of Miocene age as Bellamy suspected. Moreover, its relations to the igneous rocks are similar to those of the Idalian limestones elsewhere (4) in the island.

PLIOCENE.

The Pliocene beds are of various lithological types, but the majority are arenaceous or argillaceous and no pure limestones which can with certainty be referred to this period have been observed. The deposits consist of impersistent beds of soft sandstones, sandy marls and clays and vary much in character and fossil contents from place to place. Locally they are highly fossiliferous, and Gaudry (3, pp. 201–17) gave a list of the species which he found, but did not attempt any detailed classification of the beds and in most cases the exact position of the places in which the fossils occurred is not clearly stated, so that they cannot be identified with certainty. Moreover, most of the species in his list were collected from the deposits round the Salt Lake at Larnaca (13) which are of Pleistocene age (Middle Post-Pliocene, according to Stefani (35, p. 398)). Unger and Kotschy (15, pp. 36–47, 49) mentioned several fossiliferous Pliocene localities; their longest list of species is from a spot on the road from Polis to Chrysoku, but the fauna does not appear to correspond with any found elsewhere and this locality was not visited by the present author. The fossils collected by Bergeat (14) included some from the neighbourhood of Limassol which Simonelli (14*a*) identified and concluded might indicate either Miocene or Pliocene. The largest collection came from a succession of beds forming a hill near Nicosia of which Simonelli gave a section and a list of seventy-five species from six fossiliferous horizons. As the great majority of the shells are still living in the Mediterranean he was led to attribute to these deposits a Post-Pliocene age, but he recognized the occurrence of twelve species which are no longer living in that sea and finally seemed rather doubtful of the correlation of the beds. Many of the species in his lists have been found by the present author, and it is probable that it is the same fauna as occurs at Locality K about 3 miles south of Nicosia which is described below as Middle Pliocene. But it has not been possible to identify the precise locality of Bergeat's section.

With regard to the relative ages of the various Pliocene beds Gaudry believed that those on the Carpas were somewhat older than those in the central and southern parts of the island, but Simonelli was doubtful of this. Bellamy (1) likewise ascribes all the latter to the Newer Pliocene, though he mentions the occurrence of *Ostrea*

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[1] Sacco, *Moll. Terr. Terz. Piemonte*, pt. xvii, 1895, p. 20, t. ii, fig. 6.

[*Liostrea*] *cochlear* on a hill west of Myrtou. De Stefani (35, p. 340) was not acquainted with any deposits like those in Cyprus further east in the Mediterranean, but he was apparently ignorant of Blanckenhorn's discoveries in Syria about the same time. Blanckenhorn (16, p. 43) who considered that all the Pliocene deposits in the Mesaoria or central plain of Cyprus were of Upper Pliocene age held that there were beds of this age in the Orontes valley on the mainland which were a direct continuation of them. But a comparison of Blanckenhorn's list of so-called Middle Pliocene species from Syria with those in the present author's collections from Cyprus demonstrates that it is the Middle stage of the Pliocene rather than the Upper stage which is most abundantly represented on the island. There is now also evidence that the Lower Pliocene occurs in Cyprus, and certainly the Plaisancian stage can be recognized ; it is even possible that the Pontian also occurs, as it does in Crete (17) where Cayeux has found both and has stated that the Plaisancian there is specially marked by the presence of *Ostrea* [*Liostrea*] *cochlear* which we find to be the case also in Cyprus.

On the opposite coasts of Asia Minor and Syria it has been shown by Blanckenhorn (16), (18), (25) Schaffer (11), Toula (20), Oppenheim (19), and others (22), (23), (27), (28) that Lower, Middle, and Upper Pliocene beds are present, and Tchihatcheff[1] long ago found a large number of Pliocene fossils in Cilicia, several of which are now known to occur also in Cyprus. Blanckenhorn has observed that in northern Syria in the beds which he attributed to the Middle Pliocene (Astian) many Miocene species were present, a fact which suggests that some of those beds should perhaps be placed in the Lower Pliocene. It is noteworthy that Sacco states that *Ostrea* [*Liostrea*] *cochlear* does not range up above the Plaisancian in the Piedmont region, though Blanckenhorn records it from the Middle Pliocene of Syria and Egypt (24), Mayer-Eymar from the Saharian of Cairo,[2] and it is stated to be living now in the Mediterranean. It should be here mentioned that from the older division of the Pliocene in the Carpas Gaudry (3, p. 300) obtained this species and also the following :—*Megathyris detruncata*, *Ostrea latifrons* Desh., *O. Boblayei* Desh., *O. Virleti* Desh., *O. pseudoedulis* Desh., *Pecten opercularis* Lam., *Hinnites crispus* Bronn, *H. Dubuissoni* Defr., *Balanus tintinnabulum* Lam., *Cidaris Desmoulinsi* Sism., and *Conoclypeus anachoreta* Ag. Some of these species have been collected by the present author from other localities in the island. From Mavrospilios Gaudry also records (iii, pp. 213, 301) *Spatangus corsicus* Des. ? *Echinolampas hemisphericus* Ag. and *Echinocyamus Studeri* Ag. Simonelli (14*a*) recorded the following from Chilanemo, a locality which the author was unable to visit :—*Bittium reticulatum* Da Costa, *Pecten* (*Aequipecten*) *opercularis* Linn., *Pecten jacoboeus* Lam., *Cardium* sp. ind., *Terebratula ampulla* Br. sp.,

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[1] Tchihatcheff, *Asie Mineure*, pt. iv, "Géol.," 1869, pp. 61–94.

[2] Mayer-Eymar, *Palaeontographica*, xxx, Lief. 2, 1898, p. 73.

Spatangus sp. ind., *Anapesus serialis* Pomel. We have not found any trace in Cyprus of the Pliocene and Pleistocene freshwater deposits which Blanckenhorn (21) and others (27) have described from Syria and Palestine, and the Levantine freshwater beds of Rhodes and the Ægean islands are apparently absent. The Upper Tertiary marine fauna of the island of Rhodes [1] does not bear much resemblance to any fauna in Cyprus, though some of the Pliocene corals [2] seem to be identical or closely allied. It will be shown that the Pliocene faunas of Cyprus bear a much closer resemblance to those of Italy than of any other Mediterranean country. Blanckenhorn (16) has drawn attention to the large number of Sub-appennine species in the Middle Pliocene of Syria and Palestine, many also occurring in the corresponding beds of Cyprus. On the strength of this general resemblance of the faunas of the Italian deposits and the specific identity of many of the fossils in the beds we have largely depended on the lists of characteristic species given by Sacco [3] for the successive Tertiary horizons in Piedmont and by Gignoux (40) for southern Italy as a means of determining the age of the various Pliocene beds in Cyprus. The differences which exist in the faunas of the two areas are not greater than we would be prepared to find at such a distance apart.[4]

There is less resemblance to the faunas of the Pliocene beds of Egypt (24), (25), (34), (39), and Cyrenaica (30) than to those of Italy; the Clypeaster sandstone near Cairo which Blanckenhorn (27) correlated with the Plaisancian has not been recognized, and very few species of the Cucullata stage which he referred to the Astian have been found, though some of the species from the Pleistocene (?) deposits of the Red Sea occur (34). We may draw attention, moreover, to the many species in the Pliocene of Cyprus which occur also in the Plaisancian of Algeria (31), (32). The difficulty of determining the age of the late Tertiary beds in Cyprus is somewhat similar to that in the case of the deposits of the Red Sea and Suez, the Persian Gulf and Mombasa Island (33), as R. B. Newton particularly mentioned (34). For some palaeontologists on the strength of the mixture of extinct or Miocene forms with existing species refer them to the Mio-Pliocene, while others would put them Post-Pliocene or Pleistocene, as Simonelli (14*a*) was inclined to do with most of the beds from Cyprus. The faunas, however, of these deposits from the Red Sea and other North African localities mentioned are in no way similar to those of Cyprus which have a well-marked Mediterranean character. Apart from the palaeontological evidence of the age of the Pliocene beds in Cyprus we have the generally accepted evidence (1), (2) that there was a considerable Post-Pliocene elevation of the island and that since that event there has been no submergence sufficient for the deposition of the marine beds now found at heights of over 1,000 ft. These beds must therefore be prior to the elevation, and this conclusion rules out Simonelli's view of the age of their faunas. The stratigraphical evidence and occasional want of unconformity with the Miocene beds also suggest that old Pliocene deposits are represented in the island.

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[1] Fischer, *Mem. Soc. Géol. France*, ser. III, vol. i, pt. ii, 1877, pp. 1–74, pls. i–iii. Bukowski, *Jahrb. k.k. geol. Reichsanst.*, Bd. xlviii, 1899, Heft 4, p. 525; id., *Sitzungsber. K. Akad. Wiss. Wien*, Bd. xcviii, Abt. 1, Heft iii, 1889, pp. 208–72.

[2] Jüssen, *Sitzungsber. K. Akad. Wiss. Wien*, Bd. xcix, Abt. 2, 1889, pp. 13–33.

[3] Sacco, *Bull. Soc. Géol. France*, ser. IV, vol. v, 1905, pp. 893–916, pls. xxx, xxxi.

[4] The view expressed by De Stefani (35) that the differences in the faunas of the supposed distinct stratigraphical horizons in the Pliocene of the Mediterranean area are mainly due to bathymetric and environmental causes does not find general acceptance.

LOWER PLIOCENE.

Locality (*a*).

On ascending the hill towards the village of Simou by the side road which bends off from the main road from Paphos to Polis at the fountain situated between mileposts 76 and 77 from Nicosia we meet in the first 100 yards with greenish and greyish clays and soft marls often nodular and having thin shelly layers, interbedded 2–4 in. thick, which contain a fauna of lamellibranchs, mostly of small size, and a few gastropods, all of which are usually badly preserved. From the clays we collected the following :—

Pecten sp.
Amussium felsineum For.
,, *anconitanum* For. var. *prodalli* Sacco.
Leda Hörnesi Bell.
Pectunculus inflatus Br.
,, sp.
Cardium (*Laevicardium*) *cyprium* Br.
,, (*Pontalmyra*) cf. *bollenense* May.[1]
Corbula gibba Ol.
Nassa sp.
Foraminifera.

In the shelly bands two species of *Pecten*, a species of *Lucina* or *Dosinia* and *Vermetus intortus* have been found. One of the species of *Pecten* (*Aequipecten*) closely resembles *P. fortaui* Blanck.[2] from the Miocene of Cyrenaica and some varieties of *P. opercularis* ; the other is not identified.

The occurrence of *Amussium anconitanum* var. *prodalli* and the affinities of this species of *Pecten* and of *Cardium* (*Pont.*) cf. *bollenense* suggest that these beds should perhaps be referred to the Upper Miocene or Pontian rather than the Lower Pliocene, but they pass up without any break into the overlying undoubted Pliocene. The same beds are found on the opposite side of the main valley along the main road to Polis (*Locality a*1) between mileposts 75 and 74 from Nicosia, and the sandy clays here with thin shelly bands intercalated have yielded the following species. The specimens are mostly of small size and rather poorly preserved.

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[1] This shell, of which only one specimen was collected, seems also closely allied to *C.* (*P.*) *constantiae* Stefanescu (*Mem. Soc. Géol. France*, No. 15, 1896, p. 70, pl. vi, figs. 30, 31), from the Pontian of Roumania.

[2] Blanckenhorn, *Zeitschr. deut. geol. Gesell.*, liii, 1901, p. 121, text-fig. 11.

Cardium (*Laevicardium*) *cyprium* Br.
Tellina distorta Poli ?
Ervilia cf. *castanea* Montg.
Lucina sp.

Corbula sp.
Turritella sp.
Paludina ? sp.
Tectura virginea Mont.

(*a* 2) Above the beds containing this fauna and higher up the hill on the same side-road towards Simou we find soft sandy limestones or crumbling loose calcareous sandstones which have yielded the following species and may be referred to the Plaisancian :—

Pecten (*Flexopecten*) *inaequicostalis* Lam. var.
Cardium (*Prosodacna*) aff. *cilicianum* Toula.[1]

Venus (*Clausinella*) *Basteroti* Desh. ?
Cardita sp.

(*a* 3) Above these higher up the hill is a thick irregular succession of soft sandstones, marls, clays and sands at a height of 1,100–1,400 ft. above sea-level containing a very abundant and well-preserved fauna, usually aggregated into patches or lenses. False and irregular bedding is common, and no definite succession of beds can be established, but the fauna seems to be the same throughout. Capping these fossiliferous beds is a pebbly loam containing some huge rounded or subangular boulders of Idalian chalky limestones and of igneous rocks, frequently covered with Serpulae and small oysters. One of the boulders measured 10 × 5 × 6 ft.

The fauna of this main series of beds comprises the following species :—

Liostrea (*Pycnodonta*) *cochlear* Poli.
Ostrea lamellosa Br.
,, *edulis* var. *italica* Sacco.
,, ,, var. *Cyrnusi* Payr.
,, *Boblayei* Desh.?
,, *neglecta* Micht.
Anomia ephippium L.
,, ,, var. *sulcata* Poli.
Pecten jacobaeus L.
,, (*Flabellipecten*) *flabelliformis* Br. var. *persulcata* Sacco.
Pecten (*Flabellipecten*) *Alessii* Phil.
Arca (*Anadara*) *diluvii* Lam. var. *subantiquata* D'Orb.
Limopsis aurita Br.
Pectunculus (*Axinea*) *inflatus* Br.
,, (,,) *insubricus* Br.
,, (,,) sp.
Cardium erinaceum Lam.
,, *echinatum* Lam.
,, *tuberculatum* L.
,, aff. *Deshayesi* Payr.
,, (*Laevicardium*) *norvegicum* Spengl.
,, (*Prosodacna*) cf. *cilicianum* Toula.
Cardita sp.
Isocordia cor L.

Venus (*Clausinella*) *fasciata* Da Costa.
,, (*Ventricola*) *multilamella* Lam.
,, (,,) *casina* L.
Lucina (*Dentilucina*) *Meneghini* De Stef.
Mactra subtruncata Da Costa.
Nassa mutabilis L.
,, *semistriata* Br.
,, *limata* Chemn.
Cerithium (*Thericium*) *vulgatum* Br. var.
,, (,,) *varicosum* Br. var. *laevissima* Sacco.
Turritella subangulata Br.
,, *vermicularis* Br.
Trochus (*Monodonta*) *patulus* Br.
,, (*Gibbula*) *filiformis* De Rayn. var.
,, sp.
Dentalium variabile Desh.
,, *fossile* Schröt.
,, *rectum* L.
Vermetus (*Petaloconchus*) *intortus* Lam.
Ditrupa sp.
Lophohelia Defrancei E. and H.
Flabellum roissyanum E. and H.
Stephanotrochus ? sp.
Caryophyllia sp.

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[1] Toula (20), p. 253, t. viii, figs. 5*a*, *b*; Daus (10), p. 457.

The most abundant species in this fauna are *Isocardia cor*, *Arca diluvii*, *Pecten Alessii*, *Venus multilamella* and *Trochus patulus*. The whole facies of the fauna points to this bed being of Lower Pliocene, probably Plaisancian, age.

Locality (*b*).

A flat-topped hill between Deftera and Pera south of Nicosia which rises about 200–250 ft. above the road has a cap of coarse gravel, 10–12 ft. thick, forming its level summit which slopes slightly to the north. Below this capping are 20–30 ft. of sandy and clayey beds, passing down into greenish grey clays which continue to the base of the hill. There is a fossiliferous bed about 40 ft. below the top, much obscured by slips and talus; it has yielded a considerable number of mollusca, including the following:—

Liostrea (*Pycnodonta*) *cochlear* Poli.
Plicatula sp.
Pecten Bicknelli Sacco.
  ,, cf. *spinulosus* Münst.
  ,, (*Flabellipecten*) *flabelliformis* Br.
Amussium cristatum Brn.
Hinnites Brussonii De Serr.
Limopsis aurita Br.
  ,, ,, var. *taurobliqua* Sacco.
Nucula Jeffreysi Bell.
Cardita sp. nov. (aff. *aculeata* Poli).
Chama gryphaeoides Gualt.
Venus (*Ventricola*) *gallina* L. ?
Megaxinus bellardianus May. ?
Fusus longiroster Br.
  ,, *rostratus* Ol.
  ,, *clavatus* Br. ?
Purpura reflexa Bell.
Euthria cornea L.
Triton appeninicum Sacco. var.
Pleurotoma (*Bathytoma*) *cataphracta* Brocc.
  ,, *monilis* Brocc.
  ,, *rotata* Brocc.
Chenopus uttingeri Risso.
Nassa turrita Bors. (cf. *N. acuta* Blanck.).
  ,, *inaequicostata* Bell.
  ,, *semistriata* Br. var.
Conus antiquus Lam. ?
Turritella subangulata var. *ditropis* Font.
  ,, ,, var. *depresso-carinata* Sacco.
  ,, ,, var. *spirata* Brocc.
Natica montacuti Forbes.
  ,, *epiglottina* Lam.
Solarium humile Micht.
Dentalium variabile Desh.
  ,, *rectum* L.
Psygmobranchus (*Protula*) *firmus* Seg.

(*b* 1) A smaller and much lower hill, only 20–30 ft. high, situated a few yards to the south consists of similar fossiliferous clays capped likewise with gravel, and probably it is a slipped mass from the larger hill; the fauna, however, is slightly different. The fossils are mostly well preserved and not simply casts or impressions, and the fauna is marked by the predominance of gastropods both in species and individuals.

Pecchiola argentea Mar.
Turbo (*Ormastralium*) *fimbriatum* Bors.
Nassa Renieri Bell. ?
Natica catena Da Costa var. *helicina* Br.
Columbella (*Thiarella*) *thiara* Brocc.
Mitra Sismondae Micht. var.
Dentalium variabile Desh.
  ,, *rectum* L.

This fauna appears to mark a special facies of the Plaisancian and to belong to the lower part of that formation, as it has many Miocene affinities.

Locality (*c*).

Alongside the road from Limassol to Phinicaria shortly before the village of Yermasoyia is reached there is a small cliff which is composed of hard calcareous thick bedded unfossiliferous sandstones having thin bands of sandy limestone intercalated which have yielded the following fauna indicating the Plaisancian.

Anomia ephippium L. var. *Hörnesi* For.
Arca cf. *diluvii* Lam. var. *subantiquata* D'Orb.
Pectunculus sp.
Nucula placentina Lam.
,, sp.
Cardium (*Papillicardium*) *papillosum* Poli, var. *dertonensis* Micht.
Cardium (*Papillicardium*) cf. *hirsutum* Brn.
Cardium (*Papillicardium*) sp.
Cardita rudista Lam.
,, cf. *Bukowski* Opp.
Chama gryphaeoides Gualt.
Astarte fusca Poli.
Venus (*Timoclea*) *ovata* Penn.
Cardilia Michelotti Desh.
Lucina sp.
Lucinopsis (*Lajonkairia*) *rupestris* Br.?
Cerithium crenatum Br.

In some softer and paler impure limestones associated with the shelly bands we found the following species :—

Amussium (*Variamussium*) *felsineum* For.
Pectunculus sp.
Yoldia longa Bell.
Cardium sp.
Astarte fusca Poli.
Lucina (*Jagonia*) *reticulata* Poli.
Corbula gibba Oliv.
Vermetus (*Petaloconchus*) *intortus* Lam. var. *Woodi* Mörch.

Locality (*d*).

Near Kouklia on the north side of the road from Famagusta there is a small hill on which are exposed some greenish yellow soft sandy marls from which the following fossils (mostly fragmentary) were obtained :—

Liostrea (*Pycnodonta*) *cochlear* Poli. ?
Spondylus crassicosta Lam.
Pecten (*Palliolum*) *similis* Lask.
Pecten aff. *scissus* Favre.
,, sp. nov.

These fossils point to a Lower Pliocene age, and we may note the close resemblance of the species of *Pecten* from the Miocene of Italy described by Nelli as *Pecten chelussianus*[1] with the abundant shell here referred to *P. similis* Lask., and also the affinity of our single small specimen *P.* aff. *scissus* with the species *P.* (*Flexopecten*) *Schafferi* Kautsky[2] from the Miocene of Austria.

Locality (*e*).

Two miles west of Nicosia near Yerolakko on the road to Myrtou, a flat-topped hill on the south side of the road has a horizontal sheet of calcareous conglomerate 3 ft. thick capping it. The conglomerate consists of subangular pebbles mostly of igneous rocks and fragments of jasper, and below it come about 12 ft. of soft yellow unfossiliferous mudstones. Below them lie 3–4 ft. of soft sandy clay containing large *Pecten*, *Ostrea*, etc., of which the following is a list :—

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[1] Nelli, *Boll. Soc. Geol. Ital.*, xix, 1900, p. 389, t. iv, fig. 9.
[2] Kautsky, *Ann. Naturhist. Mus. Wien*, Bd. xlii, 1928, p. 261, t. vii, fig. 2.

Liostrea (*Pycnodonta*) *cochlear* Poli
  var. *perelliptica* Sacco.
Pecten jacobaeus L.
  ,, *varius* L.
Pecten spinosovatus Sacco.
  ,, cf. *Grayi* Micht.
Modiola mytiloides Brn.

The presence of *L. cochlear* and *P. spinosovatus* suggest that this bed should be referred to the Plaisancian rather than the Astian.

Locality (*f*).

Near milepost 60 on the road from Nicosia to the Carpas beyond the village of Ayios Symeou on the way down the steep hill towards Galliporni where Gaudry found a small fauna of Older Pliocene age there are soft marls and sandstones much obscured by landslips and rain-wash which have yielded *Liostrea* (*Pycnodonta*) *cochlear* and *Pecten bicknelli* Sacco, indicating the Plaisancian, the latter species being characteristic of it and restricted to it.

Locality (*g*).

About one mile south of the Half Way House on the Larnaca road and 13 miles from Nicosia a large high ridge consists of crumbling Idalian white chalks dipping south which are unconformably overlaid by sandy clays containing bryozoa, oysters, etc. These beds are exposed in a gully on the south side at the base of the ridge, while higher up in the gully are fragments of *Pecten*, etc. At the base of the final slope before reaching the summit and about 20–30 ft. below it there are big oysters and large *Pecten* with bryozoa, etc. in a greenish clayey sand 2–4 ft. thick. The fossils are few except the polyzoan *Eschara* in the lower sandy clays and *Ditrupa* in the upper beds which are abundant.

LOWER BEDS.

Ostrea cf. *Hörnesi* Reuss.
Pecten varius L.
  ,, sp.
Mactra subtruncata Da Costa.
Eschara sp.

UPPER BEDS.

Pecten jacobaeus L.
  ,, *syriacus* Blanck.
Ostrea crassicostata Sow.
  ,, *edulis* L. var. *Cyrnusi* Payr. ?
Thracia papyracea Poli.
Scalaria pseudoscalaris Br.
Ditrupa sp.
Indet. polyzoan.
Terebratula sp.

Probably these beds are Plaisancian in age, though the evidence is scanty.

MIDDLE PLIOCENE (Astian).

Locality (*h*).

One of the best and most extensive exposures of Pliocene beds abounding in fossils occurs on the descent to the coastal plain from the plateau along the road from Famagusta to Larnaca between the 17th and 18th mileposts. A continuous section is seen in the road-cuttings and on the sides of the hill, and the following succession in descending order can be observed. The thickness and continuity of the beds vary, some beds being apparently lenticular.

(1)	False bedded unfossiliferous sandstones	3–6 ft.
(2)	Impure calcareous marls or soft limestones containing small pebbles	1–3 ft.
(3)	Greenish yellow marls with irregular cylindrical sandy concretions ; no fossils	5–8 ft.
(4)	Friable calcareous sandstone	12–20 ft.
(5)	Grey or white hard thin bedded marls	3–4 ft.
(6)	Hard shelly marly limestones with abundant fossils passing down into	6 ft.
(7)	Soft calcareous marls with large Pectens	2–3 ft.
(8)	Thin bedded greenish grey soft sandstones becoming marly near the base	10 ft.
(9)	White nodular marly sandstones with Echinoids, lamellibranchs, etc.	12 ft.
(10)	Tough flaggy sandstone with *Thracia*	1 ft.
(11)	Soft whitish marls with Echinoids, etc.	4–5 ft.
(12)	Soft greenish marls with many *Pectens*	6–10 ft.

Below this point which is about halfway down the road the succession is not so clear, landslips and vegetation obscuring the beds. There are, however, a little lower down some curious unfossiliferous false bedded greenish sandstones, 12–15 ft. thick, weathering irregularly and traversed by several vertical dykes of hard massive sandstone 1–1½ ft. thick, and at the very base of the hill there are hard sandstones (bed 13) which yielded some large Echinoids and a few other fossils. The beds all dip slightly seawards and show some weak undulations. Fossils are abundant, but the mollusca are mostly in the state of internal casts or impressions, so that their specific identification is often difficult or impossible. The following are the lists from the different beds in the section.

BED 4.

Cardium (*Laevicardium*) *norvegicum* Spengl.
,, sp.
Cardita sp.
Thracia convexa Wood.
Diplodonta rotundata Montg. ?
Lucina cf. *globulosa* Desh.
Venus (*Timoclea*) *ovata* Penn.
Clavagella bacillum Br.
Turritella sp.
Fusus ? sp.
Ditrupa sp.
Arbacina depressa Arad.

BED 6.

Ostrea neglecta Micht. ?
Pecten jacobaeus L. ?
,, sp.
Nucula sp.
Cardium (*Trachycardium*) *multicostatum* Br.
,, (*Laevicardium*) *norvegicum* Spengl.
,, (,,) *oblongum* Chemn.
,, *echinatum* L. ?
Venus (*Clausinella*) *fasciata* Da Costa.
,, (*Timoclea*) *ovata* Penn.
Astarte sp.
Meretrix (*Callista*) *chione* L.
Diplodonta rotundata Montg.
Dosinia lupinus L. ?
Isocordia cor L. (rare).
Thracia convexa Wood.
,, *pubescens* Pult. ?
Clavagella bacillum Br.
Nassa semistriata Br.
Turritella tornata Br.
Cerithium sp.
Natica sp.
Xenophora (*Tugurium*) cf. *postextensum* Sacco.
Arbacina depressa Arad.
Echinolampas ? sp.
Flabellum cf. *roissyanum* E. and H.
Caryophyllia ? sp.

Bed 9.

Ostrea sp.
Pecten jacobaeus L.
„ *multistriatus* Poli.
„ *varius* L.
Venus (*Clausinella*) *fasciata* Da Costa.
Dosinia lupinus L. ?
Lucina cf. *globulosa* Desh.
Tapes cf. *tauroelliptica* Sacco.
Teredo norvegica Spengl.
Xenophora (*Tugurium*) cf. *postextensum* Sacco.

Serpula sp.
Membranipora sp.
Cellepora sp.
Sphaerechinus granularis Lam.
Psammechinus cf. *dubius* Ag.
Echinus siculus Checch ? [1]
„ sp.
Spatangus di Stefanoi Checch ? [2]
„ *purpureus* Müll.
„ *Lamberti* Checch. ? [3]
„ sp.

Bed 10.

Pecten jacobaeus L.
Diplodonta rotundata Montg. ?
Dosinia lupinus L. ?
Venus (*Timoclea*) *ovata* Pennt.
Clavagella bacillum Br.
Thracia convexa Wood.
„ *pubescens* Pultn. ?

Turbo ? sp.
Xenophora (*Tugurium*) cf. *postextensum* Sacco.
Echinus acutus Lk.
Brissus ? sp.
Flabellum sp.

Bed 11.

Ostrea edulis L. var. *Cyrnusi* Payr.
Pecten jacobaeus L. var.
„ *opercularis* L. var. (cf. *giavenensis* Ugol.).
„ *pes-felis* L.
„ *spinosovatus* Sacco.
„ (*Flexopecten*) *flexuosus* Poli var. *biradiata* Tib.
Pinna sp.
Modiola intermedia For. var. *gracilior* Sacco.

Cardium (*Parvicardium*) sp.
Lucina ? sp.
Thracia convexa Wood.
Tenagodes anguinus L.
Cerithiopsis ? sp.
Membranipora sp.
Cellepora ? sp.
Sphaerechinus granularis Lam.
Echinus cf. *acutus* Lam.
Spatangus di Stefanoi Checch. ?

Bed 12.

Pecten opercularis L. var.
„ *spinosovatus* Sacco.[4]
Nucula jeffreysi Bell.
Cardium aculeatum L. ?
Venus (*Timoclea*) *ovata* Penn.
Solecurtus (*Azor*) *antiquatus* Pult.

Saxicava arctica L.
Lucina ? sp.
Mactra sp.
Trochus sp.
Serpula sp.

Bed 13.

Pecten jacobaeus L.
„ *spinosovatus* Sacco.
„ *scabrellus* Lam. var.
„ aff. *Duvelzi* Nyst.
„ (*Flexopecten*) *septemradiatus* Müll.
Monia striata Br.

Pectunculus sp.
Cardium echinatum L.
„ (*Parvicardium*) *roseum* Lam.
„ (*Laevicardium*) *norvegicum* Spengl.
Venus (*Clausinella*) *fasciata* Da Costa.
Lucina cf. *globulosa* Desh.

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[1] Checchia Rispoli, *Palaeont. Italica*, vol. xxii, 1916, p. 223, t. xxv, figs. 7, 8.
[2] Ibid., vol. xiii, 1907, p. 229, t. xx, fig. 3.
[3] Ibid., vol. xiii, 1907, p. 228, t. xx, fig. 4.
[4] Sacco (*Moll. Terr. Terz. Piem*, pt. xxiv, 1897, p. 21) records this species only from the Tortonian and Plaisancian.

Lucina orbicularis Desh. ?
Diplodonta rotundata Montg. ?
Crenella sericea Brn.
Spheniopsis cf. *miotaurina* Sacco.
Clavagella bacillum Br.
Scaphander lignarius L.
Bullinella ? sp.
Xenophora (*Tugurium*) cf. *postextensum* Sacco.
Cellepora sp.
Terebratula sp.
Sphaerechinus sp.
Spatangus purpureus Müll.
,, *di Stefanoi* Checch.

The faunas from all these beds have the same general composition and many species are common throughout the whole succession of strata. There is also no stratigraphical break in the series, and the general lithological character of the beds varies but little. It is therefore necessary to regard them as representing only one stage and facies, and the palaeontological characters indicate that it should be referred to the Astian rather than the Plaisancian, for there is a general absence of those forms which range up from the Miocene into the latter and no higher, though there are a few Plaisancian species such as *Pecten spinosovatus.*

Locality (*i*).

The prominent flat-topped hill close to Athalassa Government farm has its summit covered with hard surface-limestone. Immediately below this bed in the small cliffs on the south-east side there is a soft pebbly limestone and a thin layer of tough limestone packed with masses of lamellibranchs (*Pectunculus*, etc.) which are almost impossible to extract or determine. Below this is a soft sandstone about 6 ft. thick which has yielded a few badly preserved fossils amongst which *Ostrea lamellosa*, *Cardium edule* cf. var. *contortula* Sacco, and *Pectunculus* sp. can be recognized, but most of them occur as internal casts and in poor condition.

About 50 ft. below the top of the hill on the south-east slope are similar sandstones with poor casts of two species of *Cardium* or *Cardita.* At the base of the hill there are soft yellow sandstones occurring close to the road which runs up the hillside, and these contain *P. alessii* Phil. and *P. flabelliformis* Br.

The upper beds above mentioned probably belong to the Middle or Upper Pliocene, but the lower ones can hardly be younger than Astian and may be Plaisancian on the evidence available.

Locality (*j*).

About a mile along the road leading across a plain from Athalassa farm towards the village of Yeri there is a small low ridge composed of soft sandstone containing near its base numerous large oysters (*O. edulis* var.) and Pectens (*P. jacobaeus* and *P. varius*) and casts of a species of *Cardium.* A few yards further to the south there occur very fossiliferous thick hard greyish calcareous sandstones resting on similar soft sandstones and forming another low ridge which is capped by 7–8 ft. of unfossiliferous sandstone with specially hard bands interbedded.

The hard greyish sandstones are crowded with fossils in the state of casts and impressions and comprise the following :—

Pecten sp.
Pectunculus sp.
Arca Noae L.
,, *biangula* Lam. ?
Nucula nucleus L.
Cardium (*Ringicardium*) *hians* Br.
,, (*Papillicardium*) *papillosum* Poli.
,, (*Trachycardium*) *multicostatum* Br.
,, (*Laevicardium*) *oblongum* Chemn. ?
,, *erinaceum* Lam. ?
,, *echinatum* L. ?
Cardita rudista Lam.
Meretrix (*Callista*) *chione* L.
Dosinia exoleta L.
Arcopagia corbis Brn.
Solecurtus strigilatus L.
Solecurtus dilatatus Brn.
Glycimeris Faujasi Mén.
Corbula cf. *Cocconii* Font.
Hemimactra cf. *astensis* Sacco ?
Thracia pubescens Pultn.
Lutraria oblonga Gmel. ?
Tellina sp.
Nassa musiva Br.
,, cf. *asperula* Br.
Murex cf. *brevicanthos* Siom.
,, cf. *rudis* Bon.
Tritonium heptagonum Br.
Turritella sp.
Conus sp.
Cerithium varicosum Br.
,, cf. *vulgatum* Brug.
Scaphander lignarius L.
Natica sp.

Locality (*k*).

An abundant fauna, partly of Plaisancian and partly of Astian character, is richly developed at a locality about three quarters of a mile south of milepost 3 along the road from Nicosia to Limassol, where close to the iron-bridge over a stream and behind the P.W.D. house N.67 one of the most abundantly fossiliferous series of beds found in Cyprus is exposed. The ground at the level of the road is formed of sandy clay with hard concretionary patches and irregular layers of calcareous sandstone (bed 1) containing numerous large Pectens (*P. jacobaeus*) and oysters (*O. edulis* var.). These layers form in places a solid pavement close to the stream, but above it there are softer yellow sandy clays and bluish pure clays (bed 2) 6–10 ft. thick, containing the majority of the gasteropods and lamellibranchs which are well preserved. Above these clays is another zone of large oysters, etc., forming a layer 1–3 ft. thick (bed 3). More sandy clays (bed 4) 3–4 ft. thick, with small bivalves and many examples of a small *Pecten*, occur above it and pass up into about 20 ft. of soft yellow sands (bed 5) mostly barren. Some hard ferruginous bands, 6–8 in. thick, are then interbedded with tough mudstones (bed 6) forming a second narrow shelf on the side of the small hill which rises alongside the stream ; these contain a few oysters and species of *Pecten*. Above them come about 10 ft.of soft sands (bed 7) marked by the presence of numerous oval concretions 5–8 in. long, and then 6 ft. of similar sands (bed 8) without any concretions but containing small pebbles and a few shells. A thin bed 1 ft. thick (bed 9) in their upper part contains some simple corals (*Cladocora*). The whole upper part of the hill is composed of concretionary sandy beds (bed 10) capped by nodular surface limestone, and much obscured by slipped masses of the latter. In these upper sandy beds no fossils except one echinoid and some large oysters were found.

BED 2.

Ostrea edulis L. var. *italica* Defr.
,, *edulis* L. var. *cymbaeformis* L.?
,, *crassicostata* Sow.
Pecten jacobaeus L.
,, ,, var. *striatissima* Sacco.
,, *spinosovatus* Sacco.
,, *varius* L.
,, *opercularis* L.
Amussium cristatum Brn.
Pectunculus insubricus Br.
,, sp. nov.
Arca Noae L.
,, *pectinata* Br. var.
Nucula placentina Lam.
Leda (Lembulus) pella L.
,, *(Ledina) fragilis* Chemn.
Cardium paucicostatum Sow.
,, *erinaceum* Lam.
,, *(Ringicardium) hians* Br.
Cardita rudista Lam.
,, ,, var. *perspinosa* Sacco.
,, *intermedia* Br. var.
,, sp.
Chama gryphina L.
,, *gryphoides* L.
,, *placentina* Defr. var. nov.
,, sp.
Venus (Ventricola) multilamella Lam.
,, (,,) *casina* L.
,, *(Timoclea) ovata* Penn.
Tellina serrata Br.
Lucina (Dentilucina) borealis L. ?
,, *(Myrtea) spinifera* Montg.
,, *(Codokia) leonina* Bart.
Megaxinus transversus Brn.
Glycimeris Faujasi Mén.
Gouldia minima Montg.
Mactra (Spicula) subtruncata Da Costa.
Corbula gibba Ol.
Solecurtus (Azor) antiquatus *Pult.*
Saxicavella angulata Wood.
Fusus rostratus Ol. var. *crispa* Bon.
,, *geniculatus* Bell.
Fasciolaria (Pleuroploca) lawleyana D'Anc. var. ?
Lathyrus subfimbriatus Bell. ?
Euthria cornea, L.
,, *striata* Bell.
Nassa (Uzita) limata Chemn.
Nassa (Hima) asperula Br.
,, *Semistriata* Br. var.
Murex brandaris L.
,, *(Phyllonotus) trunculus* L.
,, (,,) *conglobatus* Micht. var.
Tritonium (Lampusia) affine Desh.
Eudolium subfasciatum Sacco.
Cassidaria (Galeodea) echinophora Lam.
,, (,,) ,, var. *pliobiseriata* Sacco.
,, *(Morio) turbinata* Sacco, var.
Cassidea (semicassis) laevigata Defr.
Strombus bubonius Lam.
Acamptochetus mitraeformis Br.
Chenopus uttingeri Risso.
,, *pes-pelicani* L.
Conus pelagicus Br.
,, *Deshayesi* Bell
,, *striatulus* Br.
Cerithium (Thericium) varicosum Br. var.
Cerithiella cf. *incertula* Sacco.
Mitra fusiformis Br.
,, *subemarginata* Bell. ?
Turbo (Bolma) rugosa L.
Trochus (Oxystele) patulus Br.
,, *(Gibbula) filiformis* De Rayn.
,, *(Ampullotrochus)* cf. *subexcavatus* Wood.
Xenophora crispa Koen.
Turritella marginalis Br.
,, *vermicularis* Br.
,, *tornata* Br.
Ringicula ventricosa Sow.
Fissurella italica Defr.
Natica millepunctata Lam.
Scaphander lignarius L.
Niso terebellum Chemn.
Rissoa intersecta Wood.
Dentalium variabile Desh.
,, *entale* L.
Vermetus (Thylacodes) arenarius L.
Psygmobranchus (Protula) firmus Seg.
Membranipora sp.
Terebratula cf. *Regnoli* Mén.
,, *ampulla* Br.
Echinus (Styrechinus) sp.

The most abundant species are *Arca Noae*, *Venus multilamella*, *Corbula gibba*, *Xenophora crispa*, *Cerithium varicosum*, *Natica millepunctata* and *Chenopus uttingeri*.

Bed 3.

Ostrea fallaciosa May.
Amussium cristatum Brn.
Arca Noae L.
Cardita aculeata Poli.
Chama placentina Defr. var. *unicornaria* Lam.
Venus (*Ventricola*) *verrucosa* L.
Solecurtus dilatatus Br.
Terebratula cf. *Regnoli* Mén.

Bed 4.

Pecten scabrellus var.
,, (*Flexopecten*) *glaber* L. var.
Spondylus crassicosta Lam.
Pectunculus sp.
Cardium (*Ringicardium*) *hians* Br.
,, (*Papillicardium*) *papillosum* Poli.
Cardita sp. nov. (aff. *Laurae* Brong.).
Venus (*Ventricola*) *multilamella* Lam.
Lucina (*Myrtea*) *spinifera* Montg.
,, (*Dentilucina*) sp.
Circe sp. nov. (aff. *eximia* Hörn).
Megaxinus transversus Brn. var.
Solecurtus (*Azor*) *antiquatus* Pult.
Tellina serrata Br.
Syndosmya alba Wood.
Turbo (*Bolmo*) *rugosa* L.
,, (*Ormastralium*) *fimbriata* Bors.
Trochus (*Gibbula*) *varius* L.
,, (*Calliostoma*) *striatus* L. var.
Dentalium variabile Desh.
Cypraea europaea L.
Cerithium procrenatum Sacco, var.
,, aff. *taurocoronatum* Sacco.
Membranipora cf. *calpensis* Busk.

The most abundant species from bed 3 are *Pecten glaber* var. and *Megaxinus transversus* var. All these beds numbered 1, 2, 3 and 4 may be grouped together, and they seem to have a mixture of Plaisancian and Astian species. But *Liostrea cochlear* which according to Sacco does not occur in the Astian in Piedmont has not been found. On the other hand *Cardium hians* is according to Blanckenhorn (17, p. 6) characteristic of the 2nd Mediterranean Stage (Miocene) and only ranges up into the Lower Pliocene. But Sacco [1] records it not only from the Plaisancian but also from the Astian of Piedmont, and the Miocene form he refers to *C. burdigalinum* Lam.

The upper beds on the hillside above described yielded the following fossils :—

Bed 6.

Ostrea edulis L. var.
,, *lamellosa* Br.
Pecten varius L.

Bed 8.

Ostrea edulis L. ?
Pecten jacobaeus L.
,, *varius* L.
,, *multistriatus* Poli.
,, (*Flexopecten*) *inaequicostalis* Lam.
Chama gryphina L.
Dosinia lupinus L.
Tapes rhomboides Penn.
Cladocora caespitosa Goldf.

Bed 9.

Pecten (*Flexopecten*) *inaequicostalis* Lam.
Cladocora caespitosa Goldf.

Bed 10.

Echinolampas Hoffmanni Desor.[2]

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[1] Sacco, *Moll. Terr. Terz. Piemonte*, pt. xxvii, 1899, p. 42; id., *Bull. Soc. Géol. France*, ser. IV, vol. v, 1905, pp. 911, 914.

[2] Checchia-Rispoli, *Palaeont. Italica*, vol. xiii, 1907, p. 216 (30), t. xviii (iii), figs. 1–4, t. xix (iv), figs. 1–4.

From the small fauna obtained from the beds 6–10 we may conclude that they belong to the Middle or possibly Upper Pliocene.

Locality (*l*).

There is a long high ridge on the east side of the road to Athienou, south of Nicosia, at about half a mile after leaving the main road at Pyroi, which consists mostly of unfossiliferous clays and marls, but some soft sandy clays (bed 1) near the cultivated ground on the lower slopes have yielded a small fauna of lamellibranchs and gastropods nearly all as casts. Certain pale tough fine-grained flags (bed 2) above them yielded a few remains of fish, and above them are concretions in the sandstones and clays which are apparently barren. But considerably higher up in a side gully above heaps of slipped material and talus we found *in situ* a thin bed, 2 ft. thick, of shelly sandstone (bed 3) full of large oysters, *Pecten*, *Terebratula*, etc. The fauna of these beds as seen by the list below may be referred to the Astian. The sandy beds overlying them yielded no fossils.

Bed 1.

Pecten varius L.
,, *syriacus* Blanck.[1]
Dosinia ? sp.
Venus (*Ventricola*) *multilamella* Lam.
Turritella subangulata Br.
,, sp.
Nassa semistriata Br.

Bed 2.

Small clupeoid fish (genus indet.).

Bed 3.

Ostrea plicatula Gmel. var. ?
,, *Addollii* May.
Pecten (sp. nov.) aff. *tauroperstriatus* Sacco.
,, *jacobaeus* L.
,, *varius* L.
,, *opercularis* L. var.
Pecten (*Peplum*) *inflexus* Poli.
Amussium cristatum Brn.
Monia patelliformis L. var. *percosticillata* Sacco.
Cardium sp.
Eschara sp.
Terebratula cf. *Michelottiana* Seg.

Locality (*m*).

About 100 yards east of and above the village of Voroklini in a short nullah there are soft yellow sandstones (bed 1) which yielded only a few examples of *Terebratula* cf. *Regnoli*, *Corbula gibba*, *Cardium* ? sp. and one cast of a species of *Nerita*. Resting on them are soft buff or pinkish very fissile shales (bed 2) containing the remains of a small clupeoid (?) fish about the size of a sardine but undeterminable by Sir A. Smith Woodward who kindly examined it. Above them are hard unfossiliferous sandstones with interbedded tougher layers. The upper part of this section which forms a high cliff was inaccessible.

But in the small gully (*Locality* (m^1)) immediately behind the village of Voroklini below the cave in the escarpment small lamellibranchs occur in a poor state of preservation in the hard bands in the mass of unfossiliferous sandstones. These fossils comprise *Venus* (*Timoclea*) *ovata* Pennt. and small indeterminable species of *Cardium*, *Diplodonta* ?, etc. Whether these beds should be referred to the Middle or Upper Pliocene is uncertain, but there is a great thickness (50–70 ft.) of sandstone, etc., above them forming the upper part of the escarpment, so that they must be of a considerable age.

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[1] (16), p. 26, t. ii, figs. 3*a*, *b*.

Locality (*n*).

On the Trikomo to Lefkonico road at the 32nd milepost from Nicosia a low hill on the north side of the road consists of soft sandstones and sandy marls containing large oysters, *Pecten*, etc., and resting directly on the Idalian white chalk. The fossils comprise the following, and suggest the Astian :

Ostrea edulis L. var. *italica* Defr.
,, *lamellosa* Br.
Pecten jacobaeus L.
,, *varius* L.
,, *spinosovatus* Sacco.

Pecten syriacus Blanck.
Mactra subtruncata Da Costa.
Cardium subsociale Blanck.[1]
Lucina sp.
Schizaster ? sp.

There is a peculiar series of beds exposed along the same road in a section about 100 yards west of the village of Synkrasi. The succession is as follows in descending order :—

Hard coarsely nodular marly limestone forming top of plateau	3–4 ft.
Soft sandstones, about	20 ft.
Conglomerate	2 ft.
Red clay	1 ft.
Nodular white marls	30 ft.
Conglomerate with thin sandstone bands intercalated	12–15 ft.
Red gritty clay	4 ft.
Soft greenish sandstone	+3 ft.

The beds have a dip to the S.E. at about 20°. This is the only locality in which red clays have been observed. No fossils were found in this section.

UPPER PLIOCENE.

Locality (*o*).

On the west side of the road from Nicosia to Larnaca near the 7th milepost a conical detached hill is capped with a thin layer of calcareous cemented gravel below which is a massive bed of cavernous and concretionary sandstone about 20 ft. thick, hardened in places and irregularly weathered, but containing species of *Pecten*, especially *P. varius*, and a few other lamellibranchs as casts. Below it the sandstone becomes softer and near the base of the hill it yielded a few large specimens of *Pecten* and oysters. It rests directly on Idalian chalky limestones.

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[1] Blanckenhorn, *Zeitschr. deut. geol. Gesell.*, liii, 1901, p. 318, t. xv, figs. 6, 7.

In the upper concretionary sandstone the following were collected :—

Ostrea edulis L.
Pecten varius L.
,, (*Flabellipecten*) *Alessii* Phil.
Pectunculus transversus Lam. ?
Chama gryphina L.
Meretrix (*Callista*) *choine* L. ?
Lucina ? sp.
Dosinia exoleta L.

We may refer these beds with hesitation to the Upper rather than the Middle Pliocene.

Locality (*p*).

The cliffs of Pliocene beds immediately above the village of Pyla on the old road from Famagusta to Larnaca are cut into by a deep irregular gorge ending in a cave, and we can trace the succession from the summit downwards. A tough surface limestone composed of more or less definite layers, in all 6–10 ft. thick, is the highest of the series. Below it there is a pebbly limestone, 4–5 ft. thick, full of small pebbles. A soft nodular sandy limestone, 20–5 ft. thick, next occurs with a curious layer at its base of bedded flat sandstone pebbles, 2–3 ft. thick. Then follow nodular sandy calcareous beds 5–6 ft. thick, with many shell fragments, amongst which we can identify a small smooth *Pecten* (cf. *P. incomparabilis* Risso[1]) and *Membranipora* sp. Below these soft beds is a hard pebbly limestone thinly bedded, containing many shells difficult to extract except a large oyster (probably *O. edulis*), but *Mactra truncata* and *Cardium* sp. were also collected. This bed is about 6–8 ft. thick. Further down the gorge lower beds are exposed on the western side, and they consist of nodular greenish calcareous sandstones which only yielded a large species of *Balanus* and a few oysters. These beds may either be Middle or Upper Pliocene age, but there is not sufficient fossil evidence to decide, though it is probable from their position that they belong to the earlier stage.

PLEISTOCENE ?

As Bellamy has remarked (i, p. 37) it is not always easy to separate the Pliocene from the Pleistocene deposits, and some doubt is attached to the age of the following three occurrences which at any rate do not show any characteristic Astian fossils in their scanty faunas, and their superficial mode of occurrence strongly suggests that they are of late date.

Locality (*q*).

Between the 7th and 8th milepost from Nicosia on the Limassol road there is a gently sloping bank strewn thickly with loose oyster shells (*O. edulis* vars.) lying freely on the surface. This oyster bed seems to pass gradually into coarse banks of pebbles consisting of igneous rocks and spreading over the hill top. Below the pebble beds are soft sandy beds. On the top of a higher flat-topped hill rather further on beyond the 8th milepost there is a coarse compact conglomerate roughly bedded 8–10 ft. thick and composed of subangular and angular pebbles up to 1 ft. in length, mostly of igneous rocks, resting on soft greenish and yellow sandy clays. Probably both these coarse conglomerates are part of the same sheet, and are of Pleistocene age.

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[1] Cerulli-Irelli, *Palaeont. Ital.*, vol. xiii, 1907, p. 97, t. vi, fig. 9.

Locality (*r*).

Near Nicosia on the rough road about 1 mile beyond the Kykko monastery there is a series of low banks and ridges of shingle and grey marl in a shallow valley running approximately north and south, the surface of which is strewn in places with oysters and a few fragments of *Pecten*. The shells are also found imbedded in soft white limestone bands higher up on the low hills in the neighbourhood and also in the pebbly calcareous conglomerate and greenish sandstone which overlie the limestone. There are also here yellow sands, clays, and thin bedded sandstones capped by coarse pebble-conglomerate forming a level topped ridge on the east side of the depression and plain in which lie the oyster banks. There is no sufficient evidence from the fossils to refer these beds to the Pliocene rather than to the Pleistocene, but the fact that the fossils are mostly strewn over the surface or occur in the superficial limestones and that they form deposits like modern oyster beds inclines us to consider them as of comparatively recent age and to refer them to the Pleistocene. The fossils, which are almost entirely oysters, comprise the following :—

Ostrea edulis L.
,, ,, var. *subgibbosa* D'Orb.
,, cf. *Forskalii* Chemn. ?

Pecten varius L.
Balanus tintinnabulum L.

Conclusions.

A great deal more field work and collecting will be necessary before we have a complete knowledge of the Tertiary beds of Cyprus. But from the foregoing observations and collections of fossils from many localities and deposits, the following results appear to be established : (1) The Miocene beds (Idalian) include representatives of the Langhian, Helvetian, and probably the Tortonian; (2) the Pliocene beds comprise deposits of which some may be referred to the Plaisancian and others to the Astian and a few probably to a higher stage; (3) the faunas of both the Miocene and Pliocene beds bear a much closer resemblance to those of the Italian region than they do to those of Egypt or North Africa ; (4) there are several species which occur in the Miocene and also in the Pliocene of North Syria, and just as in the case of this country (16, p. 38) a large number of Miocene forms range up into the Pliocene.

The description of some new species and varieties in the above lists will form a subsequent contribution. Professor J. W. Gregory and Dr. Ethel Currie have kindly examined the few Miocene echinoids which were collected, and the latter has written a short note on the specimens. Mr. A. G. Brighton is looking over the numerous Pliocene echinoids, but his results are not yet available. The collections of Miocene and Pliocene fossils from Cyprus in the British Museum (Natural History) have been examined, but most of them have been collected from ill-defined localities, so that no attempt has been made to base any conclusions on them.

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The Age of the Connemara Schists and of their Metamorphism.

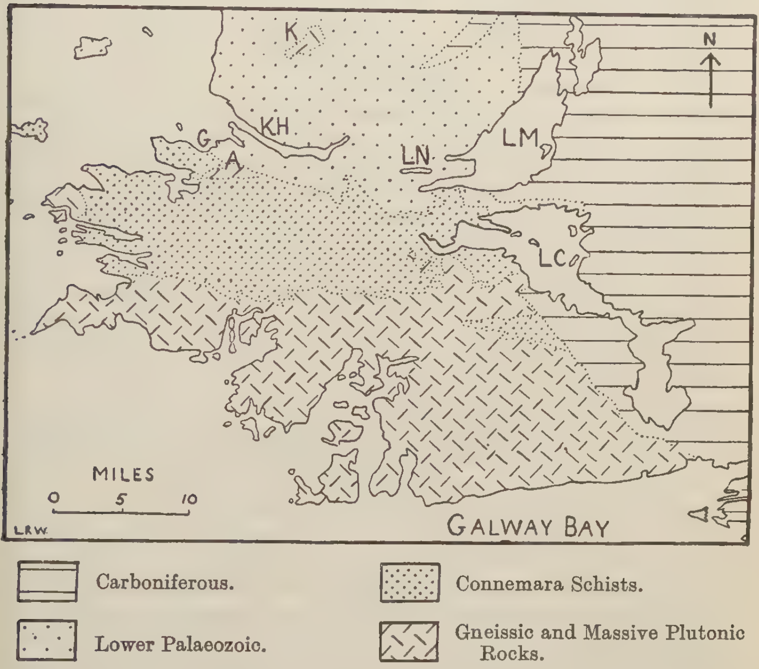
By L. R. Wager, B.A., F.G.S., The University, Reading, and G. Andrew, M.Sc., F.G.S.

In Connemara and South Mayo, three main rock groups have been distinguished. The first group, largely developed in South Mayo (see sketch-map), consists of slates, phyllites, grits, conglomerates and thin limestones, and, although these rocks are much cleaved, sufficient fossils have been found to prove that they vary in age from Arenig to Ludlow. The second group of rocks, occurring principally in northern Connemara, consists essentially of quartzites, limestones and schists, and in this group fossils have not been found. In the pelitic schists of this group, biotite, garnet, staurolite and fibrous sillimanite are of widespread occurrence, proving that the group as a whole is in a state of medium to high grade regional metamorphism. We propose that the term Connemara Schists, which has previously only been used vaguely, should be restricted to this group. The third group, occurring in Southern Connemara, is a gneissic series which was tentatively correlated with the Lewisian Gneiss by early workers, and which is indeed remarkably similar to it in general appearance. Later work by Callaway (1887) and McHenry (1903) has, however, shown that these gneisses are not overlain unconformably by the Connemara schists, but are orthogneisses intrusive into them. Their age, therefore, relative to the Connemara Schists, is not in doubt.

In the field the rocks, which may be proved to be of Lower Palaeozoic age by their fossils, show much the same amount of cleavage as the Connemara Schists, and they also seem to show a similar type of small scale folding. Before the significance of Barrow's zones of increasing regional metamorphism had been fully realized, general appearances were used as the criteria for estimating intensity of metamorphism. Geikie (1896) and Kilroe (1907) were thus led to believe that the Lower Palaeozoic rocks of South Mayo had undergone a metamorphism of much the same degree as the Connemara Schists. While not definitely committing themselves, they favoured the view that the Connemara Schists might consist largely, or even entirely, of Lower Palaeozoic rocks in which local metamorphism of a slightly more intense kind had effectively destroyed the fossil evidence for their age.

The junction between the Lower Palaeozoic rocks and the Connemara Schists is often complicated by faulting and igneous intrusion. This seems to be the case with all exposures of the junction of the Connemara Schists and the Arenig rocks. But, between the Wenlock and the Connemara Schists, south of the entrance to Killary Harbour, there is an unconformity which is well exposed and which is quite uncomplicated by faulting or igneous intrusion. Here the lowest Wenlock, resting directly on the schists, is a conglomerate, resembling in the size of the boulders and in general appearance some of the Old Red Sandstone conglomerates of Scotland, although the finer grained cementing material is distinctly schistose. This unconformity has been described by the Survey (1878), by Kilroe (1907), and by Maufe and Carruthers (1909). Kilroe (1907, p. 153) also found that in the Lough Nafooey area, twelve miles further east, the Llandovery beds are absent as a result of an unconformity, and this seems to have been partly confirmed by Gardiner and Reynolds (1914). The finding of an inter-Lower Palaeozoic unconformity made Kilroe doubtful of ascribing any great importance to the Wenlock unconformity south of Killary Harbour. He considered that the schists below the unconformity, south of Killary Harbour, might well be Lower Palaeozoic rocks which were slightly folded during early Silurian times, but which were brought to their present state of metamorphism during a post-Wenlock (in fact Caledonian) earth movement. Such a theory would imply that both the Wenlock and the Connemara Schists unconformably beneath them, were at the same grade of regional metamorphism.

Callaway (1887, p. 523) in discussing the age of the igneous rocks intruded into the Connemara Schists, has shown that the "Silurian" conglomerates of Killary Harbour are mainly composed of large rounded fragments of igneous and metamorphic rocks. He gave a rough description of some of these rocks and pointed out that they closely resemble rocks found intruded into the Connemara Schists. Maufe and Carruthers (1909, p. 9) confirm in a general way Callaway's statements. However, without the discovery of some unique rock type in both the Arenig conglomerates and the Connemara Schists, this line of evidence for the age of the Connemara Schists is inconclusive.



Geological Sketch-map of S. Mayo and W. Galway (including Connemara). A, Altnagaighera, G, Gowlaun; K, Knockaskeheen; KH, Killary Harbour; LC, Lough Corrib; LM, Lough Mask; LN, Lough Nafooey.

During a rapid traverse made in the summer of 1929, the rocks of proved Lower Paleozoic age in South Mayo, were seen to be in a low state of regional metamorphism except round the granite of Knockaskeheen, where contact metamorphic effects are admirably displayed. Many of the pelitic rocks are chlorite and sericite-schists and from statements by Kilroe (1907, p. 156) and Maufe and Carruthers (1909) and from lack of comment by Reynolds and Gardiner on any unusual metamorphism in the Lower Palaeozoics about Lough Mask, it is fairly certain that higher grades of regionally metamorphosed rocks do not exist among the Lower Palaeozoic rocks of South Mayo. This is in striking contrast with the Connemara Schists, with which one of us (L. R. W.) has become fairly widely acquainted during several field seasons on their southern margin and which, as has already been stated, carry index minerals of medium to high zones of regional metamorphism.

The general contrast in metamorphic grade between the two groups suggested that it would be desirable to examine the unconformity which exists between them, with a view to deciding if the change in metamorphic grade took place abruptly at the unconformity. On the coast at Gowlaun, three miles south-west of the entrance to Killary Harbour, it was found that, within a hundred yards of the unconformity, the lower series included a somewhat decomposed pelitic schist in which were abundant garnets. A little further from the unconformity fresh biotite-schists occur. The rocks immediately below the unconformity are therefore at an intermediate grade of regional metamorphism. In the Wenlock rocks above the unconformity, the amount of cleavage or schistosity is in a general way the same as that of the lower series, but the only minerals developed in the pelitic material of the conglomerate by the regional metamorphism, are chlorite and sericite. These minerals indicate a low grade of regional metamorphism. At Gowlaun, therefore, where the unconformity is free from complications due to faulting and intrusion, there is a considerable metamorphic break, which proves the unconformity to be an important one. Confirming this, the Wenlock conglomerate on Altnagaighera is found to rest unconformably on a biotite-orthogneiss which *lit par lit* intrudes the Connemara Schists but not the Wenlock. Since in Great Britain the Lower Palaeozoic was a period of deposition with only intraformational earth movements, the existence of this important metamorphic break between the Wenlock and the Connemara Schists proves definitely that the Connemara Schists are Pre-Cambrian in age. It proves also, as a corollary, that the regional metamorphism which produced the Connemara Schists must be Pre-Cambrian and not Caledonian in age.

In so far as extrapolation to other areas was justified, the Connemara and South Mayo district was considered by Kilroe and Geikie to support the view that the medium to high grade regionally metamorphosed rocks of Scotland might be partly made up of Lower Palaeozoic rocks. The considerable metamorphic break which we have found to occur at the unconformity between the Wenlock and the Connemara Schists now proves a view for which Callaway and Maufe and Carruthers had already given some evidence, namely that the Connemara Schists are Pre-Cambrian in age and that their moderate to high grade regional metamorphism was also produced in Pre-Cambrian times. On the other hand there is good reason to believe that the proved Lower Palaeozoic rocks, resting on the Connemara Schists, do not rise above a low grade of regional metamorphism. While apparently Pre-Cambrian sediments in Great Britain may range from low to high grades of regional metamorphism, the Connemara and South Mayo area now affords yet another piece of evidence in favour of the view that in Great Britain the Lower Palaeozoic sediments were not converted to high grade schists by the Caledonian earth movements, as they apparently were in Scandinavia.

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On a New Species of Eurhinosaurus in the British Museum.

By W. E. Swinton, B.Sc., F.G.S.

(*Published by permission of the Trustees of the British Museum.*)

IN 1928 the Trustees of the British Museum purchased for the Geological Department the skeleton of a large Ichthyosaur then being prepared in the workshop of Dr. B. Hauff in Holzmaden. During its preparation the skeleton was, with the permission of the Department, studied by Professor F. von Huene, of Tübingen, who subsequently published an adequate description and figure of it, and who reached the conclusion that it was probably a new species. Since I consider that the specimen is undoubtedly different from the others so far described as *Eurhinosaurus longirostris* I propose here to review briefly its main characteristics under a new specific name. As von Huene has done the most important work on the genus it is with great pleasure that I name this new species in his honour.

Eurhinosaurus huenei sp. nov.

Eurhinosaurus sp. von Huene. *N. Jahrb. Min. Geol. Palëont.*, Stuttgart. lix, Abt. B. 1928, p. 471–84. Pl. xxxvii.

Diagnosis.—Paddles long and slender, the fore paddle with a comparatively long fourth digital row; hind paddles with numerous notched paddle bones. Coracoid with a very narrow anterior incision. Ischium and pubis broader distally than in the type species. 44 presacral vertebrae.

Holotype.—Almost complete skeleton in the British Museum, Regd. Geol. Dept. R.5465.

Horizon and Locality.—Upper Lias, "Lage II, 10, Posidonienschiefer." Holzmaden.

Remarks.—Von Huene's account of the specimen is full and accurate so that there is no need to describe the skeleton in any detail. It must suffice to say that in the characters of several of the bones and in the relative proportions of the skull and various body measurements it is obvious that the specimen is not adult. Partly on this ground von Huene has hesitated to call it a new species, but he says it is probably new and lists five features in which it differs from the other and type species (*E. longirostris*) of the genus. These features are practically all listed in the diagnosis and it is important to consider whether any of them are due to the youth of the specimen. Von Huene used for comparison the complete skeletons of *E. longirostris* in Tübingen and Stuttgart, but recently the Senckenberg Museum of Frankfurt has obtained an excellent specimen which has been briefly noticed by Dr. Drevermann (*Natur und Museum*, Bd. 60, Heft 1, Jan., 1930, pp. 21–3) and which shows several features not observable in the other skeletons of *E. longirostris*.

The main features of the British Museum specimen may therefore be described as follows. The paddles are well preserved and unusually slender, having proportions quite unlike the other specimens of the genus. There is no reason to assume that the slenderness of the paddles is a youthful character, indeed, the contrary is the case, for paddles become more slender with age. The fore paddle is composed of four main rows of digital paddle bones, the third row, as usual, dividing into two, so that the paddle has eventually five digital rows. The last, the morphological fourth, has a comparatively long digital row. This is not well seen in the Tübingen or Stuttgart skeletons but the Frankfurt example also has a fourth row but of smaller dimensions. Apart from the greater number of its constituents the paddle of *E. huenei* is definitely of different character, and while I agree that there is no great importance to be attached to the number of paddle bones in the last row, I do not think that the characters of the paddle can be explained by age or individual variation. The same conclusion may be reached with reference to the hind paddle which is also very long and narrow. It possesses the largest known number of notched paddle bones (" scissen ") for the genus, but this character is apparently very variable. None the less, although *E. longirostris* shows variation in this respect, there is an unusually large number of " scissen " in this specimen. The narrow anterior incision of the coracoid is another quite distinct feature which is not attributable to age. Likewise may be mentioned the breadth of the distal parts of the ischium and pubis. It is unlikely that this is due to age, and there is less probability of its being an individual or sexual, rather than a specific, character. The most decisive feature is the position of the sacral vertebra. In *E. huenei* the number of presacral vertebrae is 44, in *E. longirostris* it is 47 : and the position of the sacral vertebra is unmistakable. There is also a difference in the number of centra between the sacral vertebra and the angle of the tail, the London specimen having 47, and the Stuttgart (*E. longirostris*) 40. This is really quite a considerable difference for von Huene himself has shown that in the Ichthyosaurs, so far as observable, the position of sacral vertebrae in the same species is constant. Thus it is reasonably certain that this difference of position of the sacral centrum is not to be explained by individual variation, or by age.

The combination, therefore, of the foregoing six features seems to indicate clearly that in this British Museum specimen of *Eurhinosaurus* we have the representative of a new species.

REVIEWS.

The Nappe Theory in the Alps. By Franz Heritsch. Translated by P. G. H. Boswell. pp. xxx + 228, with 48 text-figures, and 8 plates containing 16 photographic views. London: Methuen and Co., 1929. 14*s*. net.

THE structure of the Alps as interpreted by the Swiss geologists is well-known in England, and as regards its essentials there seems to be complete agreement amongst West Alpine geologists. One or two, indeed, are so certain they are right that the natural man revolts and, taught by common experience and by the history of geology, feels almost as sure that they are wrong. This is due, perhaps, to his unregenerate nature, for the interpretation rests upon a solid ground of fieldwork. When, however, we come to the question of the causes which have produced the structure and the way in which they acted, it is different. There is no solid ground. The playground of Europe has become the fairyland of science, where the laws of mechanics are not inviolable, small forces may overcome great ones, and friction may be neglected except as a handy resource on occasion.

It was partly the mechanical difficulties that led Ampferer to formulate his hypothesis of a Verschluckungszone, which transfers the difficulties to an unknown interior ; but this was not all. Since the days of Rothpletz, the workers in the Eastern Alps, with some notable exceptions, have not seen eye to eye with their Swiss confrères. In their view recumbent folds do not play so large a part, and never reach the gigantic dimensions required by the Swiss interpretation. More influence is attributed to thrust-planes, to steeply inclined minor thrusts and to isoclinal packing, but the horizontal displacements have been small compared with those imagined by the Swiss geologists.

The East Alpine views seem to be almost unknown to English geologists, and Professor Boswell has performed a real service by placing before them this translation of Professor Heritsch's book. So far as the Eastern Alps are concerned Professor Heritsch is an opponent of the Nappe Theory in its extreme forms. He does not believe that we have here a series of colossal recumbent folds piled one above another, nor will he allow that the material of the northern Limestone Alps was deposited to the south of the present range. Like most East Alpine geologists, including Kober, who does not belong to the East Alpine school of thought, he recognizes an important period of nappe formation in pre-Gosau times. He finds evidence of movements to the west or north-west as well as the more widespread northerly movement. And he thinks that Hercynian relics had an important influence upon, for instance, the distribution of facies.

These are some of the points in which the East Alpine school differs from that of the West. But Professor Heritsch does not unduly stress them. He is conspicuously fair-minded in his exposition. Perhaps he is almost too fair-minded. In his anxiety to do justice to his opponents, he scarcely does justice to himself. He allows them to speak for themselves and it is not always clear where he agrees and where he differs. He is not a propagandist and he does his best to present an unbiassed review of the present position.

On his last page he touches, very briefly, a point of considerable interest. According to the Swiss interpretation the aerial continuations of the recumbent folds rise miles above the present summits. The amount of material which has been removed by denudation must be enormous, far exceeding the bulk of the existing Alps reckoned from sea-level; and the denudation occurred mostly during the later part of the Tertiary period. Where is that material now?

In connection with this question it is worthy of note that in front of the Himalayas, in the Indo-Gangetic depression, isostasy suggests that loose material reaches downwards to a depth of about 40,000 ft. It would be interesting to know the depth of similar material in the plain of Switzerland and in the plain of the Upper Danube.

P. L.

THE GEOLOGY OF VENEZUELA AND TRINIDAD. By R. A. LIDDLE. Texas, 1928.

IN this volume of over 500 pages the geology and physiography of Venezuela and Trinidad have been summarized in a full and systematic manner. The author spent five years in the field, and while fully acknowledging the work of other geological writers and explorers, he has evidently visited the greater part of the region he describes. The book is divided into two parts—Venezuela and Trinidad—and the same scheme of treatment is employed in both cases. Glancing at the map one realizes that the island is merely the north-east corner of Venezuela fortuitously separated by a minor sheet of water, and that logically the geological divisions of Trinidad should be considered in each instance with those of the mainland, but, since Trinidad has been worked out in so much greater detail as the result of the activities of many oil companies, a separate treatment is no doubt a matter of convenience to most readers.

In Part I (Venezuela) nine chapters deal with physiography, the country being divided for descriptive purposes into a number of major areas differing in many characteristics: seven more with the geology: the concluding chapter summarizes the mineral resources. Part II (Trinidad) is on the same plan.

The Orinoco delta region, owing to the deposition of much sediment, is slowly sinking, but at such a rate as more than to counterbalance deposition. The Orinoco valley system occupies a geosyncline plunging to the east, between the rigid Guayana land mass on the south and the mountain ranges on the north. The oldest rocks are granitic gneisses of Archaean age, constituting the floor of the Guayana Highlands; a younger group of metamorphics, derived from Palaeozoic sediments, consists of quartzites and is associated with the older. Rocks equivalent in age to these quartzites occur in the Venezuelan Andes and in the Coast Range. A still younger group are altered basal Cretaceous sediments. The author notes that on the Colombian-Venezuelan border fragments of mica-schist have been found in the rivers, but not in place; this rock he considers to be pre-Devonian at least. Recently the reviewer found granitic gneiss, on the western flank of the Colombian Andes (Eastern Cordillera), near Ocaña, which is probably to be referred to the Archaean also. Mica-schists and Carboniferous shales and limestone, with *Productus*, *Fusulina*, corals and brachiopods, were also found to the east of Ocaña, all being intruded into by granite: the mica schists may be the same as, or comparable with, the Venezuelan occurrence. It is to be remarked that definite Carboniferous rocks have not yet been found on the Venezuelan side of the Cordillera.

Of sedimentary rocks, Lower and Middle Devonian occur in the north-west and in the Venezuelan Andes region. Next in age, in the same areas, is a thick series of sandstones, shales, and limestones predominantly red in colour and hence named the Old Red Series. No reliable fossils have yet been found and their age can be referred only broadly to some period between Middle Devonian and Cretaceous. The Cretaceous sea covered probably the greater part of the country, and its deposits now outcrop in the more mountainous regions, but Tertiary beds, masked by Pleistocene in the great synclinal of the Orinoco valley system, cover a large area, especially in the Maracaibo Basin and in Trinidad. The thickness of Tertiary deposits is just over 10,000 ft.; in Perú it is some 27,000 feet, and in Colombia not much less. The difference between the development of these rocks in South America and in the British Isles is striking. Petroleum occurs in the Cretaceous, as also it does in these rocks in Colombia, but the producing fields are sited in the Oligocene and Miocene.

There is an unfortunate mistake in the make-up of the book in regard to the page-headings, all the Tertiary coming under "Mesozoic"; this is noted in a correction slip, but tends to a little confusion. The title "Physiography" to chapter i really includes the first nine chapters, as similarly the title to chapter x, "Geology" covers the following five. The paper, type, and general production of the book are excellent; there are numerous interesting photographs and some folder diagrams. The map and correlation table at the end is well done, and evidences a large amount of thought and knowledge in its preparation. To anyone wishing to have a concise and authoritative account of what is known of the geology of Venezuela and Trinidad, especially for the purpose of doing field-work in these countries, the volume can be strongly recommended.

C. B. B.

DEPOSITION OF THE SEDIMENTARY ROCKS. By J. E. MARR. pp. vi + 245. Cambridge University Press, 1929. Price 7*s.* 6*d.* net.

IN the early days of stratigraphy, even after the value of fossils had been recognized, practical considerations required, as in new districts they still require, that the first lines drawn upon a geological map should be lithological. Close attention was paid to the beds themselves and questions of the conditions under which they were deposited occupied a large place in the thoughts of geologists. With the rise of stratigraphical palaeontology it became evident that lithological lines are seldom exactly chronological, and attempts at a more accurate chronology led to the introduction of the zonal method. By the end of last century, precise correlation had become the chief aim of stratigraphers, and in countries which were ripe for the zonal method a type of stratigraphy was developed which was very necessary, very interesting to the geologists working at the formation concerned, very dull to the rest, and very repellent to students. The close and detailed work required by the method brought with it a neglect of wider problems, and conditions of deposition were not often seriously discussed. Discussions of the sort were in fact discouraged. They were not work, and in the highest circles such subjects were considered unsuitable for the young, though the elders might discourse about them in their lighter moments. Since those days investigation of sediments, both ancient and modern, has proceeded far enough to provide a firmer groundwork and it is now more freely recognized that after the order of events has been determined it is not an idle occupation to seek to know what the events were.

Professor Marr's aim in this book is to make such an occupation more effective. A sense of duty to his science has led him to introduce preliminary chapters on chronology and correlation, but these are outside his present purpose. It is the sediments themselves that occupy him, and not the order in which they were laid down. He brings together the observations that have been made on deposits now forming, and his main theme is to relate their characters to the conditions under which they are deposited. The ideal would be to establish criteria by which the conditions of deposition could be inferred from the characters of the sediment. It would then be possible to determine the conditions that prevailed in past periods. In general the ideal has not yet been reached, but Professor Marr shows how far we have gone towards it.

The arrangement of the book is according to conditions. There is a section on deposits in land areas and another on deposits in the sea. The former might have been extended with advantage, even at the expense of the introductory chapters. The latter rightly occupies the greater part of the book. In dealing with these marine deposits, Professor Marr adopts a simplified form of Murray's grouping. He recognizes from the shore outwards a belt of variable deposit, a mud belt and an organic belt. Some such grouping is necessary for purposes of description, but no grouping can correspond very closely with the facts. Professor Marr's organic belt includes the oceanic oozes and also the organic deposits forming in shallower water. The latter are by far the most important to geologists, and many of them, such as oyster beds and mussel banks, lie far within the mud line.

In dealing with the sediments now forming Professor Marr continually illustrates his points by reference to the sediments of past periods, and these illustrations are perhaps the most valuable and interesting parts of the book. As he points out on an early page, although in general the present is the key to the past, yet in many cases the past is the key to the present, for the reason that the past is sometimes more completely exposed to our view. Red and green muds may be mentioned as affording an example. The oceanographer finds no particular connection, but the frequent association of red and green deposits in the geological series shows that in some way the connection is very close.

In the section on the land there is a reversal of order which must be due to some accident. Proceeding from pole to equator the tundras are said to be succeeded by the steppes and the latter by the temperate forest. Through Russia, Siberia, and North America the forest belt lies between the tundras and the steppes. It is also said that the forest belt, though well developed in Western Europe, becomes less clearly defined to the East. Here West and East have evidently been transposed.

These are small matters which do not affect the usefulness of the work. It is not a book to read so much as a book to think about.

It is, indeed, very easy to read, but the reader who does no more will miss its chief lessons. It is not too much to hope that it will revive the drooping spirit of Stratigraphy, now sinking beneath the burden of its overgrown body.

P. L.

Handbook of the Geology of Great Britain. Edited by J. W. Evans and C. J. Stubblefield. pp xii + 556, with 67 illustrations. London: Thomas Murby and Co., 1929. Price 24*s*.

IN an introductory note Dr. Evans details the interesting circumstances under which the appearance of the original German edition was made possible during the war, the military authorities on both sides permitting transmission of proofs through the helping hands of Professor Molengraaff in Holland. Further, it is explained how the royalties accruing to the original authors were used in the purchase of the copyright, so that this revised edition could be issued by an English publishing firm. The geology of Ireland has been dealt with in a separate work, which has already appeared, hence the name of the late Professor Grenville Cole disappears from the list of contributors; Mr. Osborne White has also withdrawn: otherwise the names of all the original authors still remain, with in addition Professor E. J. Garwood, Mr. W. B. Wright, Dr. H. C. Versey, Professor P. G. H. Boswell, Dr. G. Slater, Mr. H. Dewey and Dr. G. H. Plymen as accessions, bringing the total number up to seventeen, as against the original dozen. In the editorship Dr. Stubblefield has taken part owing to the frequent absences abroad of Dr. Evans.

In reviewing a book of this kind, a special difficulty inevitably presents itself: it is so easy to pick out faults and omissions and so hard to do justice to the enormous amount of patient and accurate labour expended on the rest of the work, therefore, if this present notice should appear to some readers to be mainly a mass of carping criticism, it is hoped that they will bear this point in mind. The book is in point of fact a mine of accurate information, and especially for the stratigrapher it is invaluable as a reference book, but the reviewers cannot help feeling that the interests of those with a different outlook have not been sufficiently considered. There are other things in geology besides stratigraphy, and even the laborious record of lithological variations, without any explanation of their causes, does not help much towards a visualization of the history of the past. In this edition, as in the earlier one, there are some admirable sections, contributed by Dr. Harker, on the igneous rocks that accompany the systems, but in many cases these are obviously so compressed that they scarcely do justice to their subject. It might have been wished that this competent authority had been given a freer hand, since igneous activity of whatever age should be regarded as a most important part of the regional geology of an area, especially in relation to orogeny. Dr. Harker's sections, as estimated from the table of contents, occupy about 36 out of a total of 550 pages.

The weakest part of the whole work is undoubtedly its neglect of tectonics. The first section, the "Morphology of England and Wales", runs to three pages; it is adorned by two footnotes, referring to points of minute detail and there is no bibliography. In the section of similar scope dealing with Scotland, of about 6 pages, Professor Gregory has refrained from giving any references at all, perhaps wisely, taking into account the vastness of the literature. The tectonic map of the British Isles, which in the German edition was in many separate pieces, as text-figures, is here presented, as a single folding sheet, but it does not thereby gain much in lucidity owing to the multiplicity of detail and the absence of any general systematic representation of the main structural lines. Eastern England between the Thames and north Yorkshire is still a blank, although much is now known as to the underground structure of that area.

A similar line of criticism also applies to the treatment of tectonic matters in the text. It seems rather absurd for example to write of the Malvernian (we should prefer Malvernoid) movement as post-Carboniferous, when it has so clearly been an active diastrophic line since early Pre-cambrian times. This is the side of tectonics that needs stressing in a book of this kind. The Bertrand principle of the continuity of folding is of primary significance in British stratigraphy. It is not only the initiation of a fold-movement that is important, but the fact that over and over again folding has been renewed along old lines, be they Charnoid, Malvernoid, Caledonoid or Armoricanoid. Stratigraphy and tectonics should in these days never be divorced from each other; they are mutually interdependent. Surely the editors might have seen to this, for it makes for continuity and without it the facts degenerate into a thing of shreds and patches, and no matter how well each patch is shaped there is no cohesion between them. It should be mentioned, however, that Professor Kendall and Professor Boswell have paid due attention to tectonics in their chapters, while Dr. Versey has done his best with that rather unpromising system from this point of view, the Permian.

The chapters on the Pre-cambrian rocks of England and Wales and of Scotland, which are somewhat disappointing, especially as regards the Scottish Highlands, are of necessity mainly structural and petrological, but otherwise the outlook of the authors is frankly in the direction of palaeontology. Here again, as in so large a part of modern stratigraphical literature, the ordinary working geologist is faced by the fact that the modern generic name of a fossil conveys nothing to him: it is only by recognition of the specific name that he can sometimes discover what the author is talking about. As a rule he finds himself submerged in a whirling flood of sesquipedalian nomenclature, full of sound and fury, signifying nothing but the pedantry of museum specialists. Species-mongering is perhaps out of date, but genus-mongering is more rampant than ever. Here perhaps one may plead for the use of the older name, in brackets, for the convenience of those less well up in the latest development of systematic palaeontology.

Again the treatment of economic matters is very unequal in the different sections. Coal is naturally dealt with adequately by Professor Kendall in the Upper Carboniferous chapter, and Professor Garwood has three pages on the economics of the Lower Carboniferous, but search has failed to reveal any account of the ore deposits of Wales or the Lake District. There are no entries in the index referring to any of these, or to the tin-veins of Cornwall, though these last are incidentally mentioned at least twice. Dr. Morley Davies gives a table of iron ores and building stones in the Jurassic, and Professor Boswell has economic sections for the Cretaceous and Tertiary, but many chapters have been drawn blank in this respect.

Having thus let themselves go somewhat on certain points, which except in the case of tectonics are matters of detail, the reviewers can only conclude by repeating what has already been said in an earlier paragraph, that within limits this is a valuable work, compiled with care, well written and well got up ; its faults are mainly those of omission, as is almost inevitable in a book of this kind. But frankly, as a whole it is not inspiring, and it is difficult to believe that British stratigraphical geology is in reality so dull and so completely out of touch with modern progress in other lands as this volume appears to indicate.

G. L. E.
R. H. R.

IPOTESI E TEORIE GEOTETTONICHE. By PROF. M. GORTANI, Giornale di Geologia, vol. iii, 1928. pp. 3–133.

FOR many years past, it has been apparent to the present reviewer that the greater part of the work of the Italian School of Geology receives little or no recognition in this country, and this is all the more to be deplored in that Italy was in reality the cradle of the science. When contrasted with the absurdities of eighteenth century geology in more northern lands, there is a strangely modern ring about the ideas of Leonardo da Vinci, of Girolamo Frascatorio, and of the Catholic Bishop Nicolas Steno, the founder of crystallography and of detailed stratigraphy, while at a slightly later date came Vallisneri and Lazzaro Moro. One hundred years ago Sir Charles Lyell drew attention to the surpassing interest of the geology of that country, but except in so far as regards vulcanicity and earthquakes, all this is practically ignored by English writers.

Nevertheless it is clear that there are in Italy geologists of the first rank, as is evidenced by the memoir now under review.

In this Professor Michele Gortani of Bologna gives an admirable recension of the whole vast subject of tectonic theory, critical and bibliographical, with a clear exposition of his own conclusions, evidently the result of intensive study and wide reading in many languages. The whole is well worth reading. The following is a (slightly condensed) translation of the concluding summary.

"The theories may be divided into groups. Some may be definitely set aside, even as subsidiary causes: others are capable only of explaining isolated phenomena, such as special varieties of folding, or processes in geosynclinals. Among these are the theories of sliding, of thermal expansion, or of magmatic pressures. Others again, which cannot themselves be considered as orogenetic theories, nevertheless furnish fundamental principles, such as isostasy, or throw light on phenomena such as differences of density, of volume or of state in the deeper regions of the crust or in the regions immediately underlying these; especially the theories based on crystallization, magmatic differentiation, and radioactivity.

There then remain in the field, two contrasted fundamental ideas. On the one side is the theory of contraction, coupled with the permanence of the main lines of terrestrial relief and the origin of mountain chains, due to causes inherent in the planet itself. On the other hand, we have the group of theories of continental drift and deep-seated currents, with the principle of the mobility of the greater masses and the foldings connected therewith, developed under the influence of astronomical agencies, especially by the rotation of the earth and the attraction of the sun and moon.

In this discussion the contraction theory is rejected, and the theory of deep-seated currents is regarded as inadequate. Continental drift in Wegener's sense does not seem to correspond with the facts. Only a combination of the two principles, continental movement due to centrifugal force and deep-seated currents due to this cause or some other, appears to be capable of explaining the various phenomena.

The only attempt in this direction, that of Staub, however praiseworthy, does not yet present a satisfactory solution. It should be worked out afresh, taking into account gravitation currents and other causes which might give rise to movements of deep-seated masses, and also the progressive slowing down of the earth's rotation due to tidal friction. The cycles should be made to correspond better with geological evidence, and it is necessary to abandon the explanation of climatic phenomena by continental displacement alone. Only on such a basis is it possible to construct a geotectonic theory in harmony with modern exigencies and really useful as a working hypothesis."

This translation is here offered as a summary of what a leading Italian geologist is thinking on the subject.

OBITUARY.

Edwin Tulley Newton.

Born, May, 1840. Died, 28th January, 1930.

Full of years and honours, and beloved by all who knew him, Mr. E. T. Newton passed peacefully away on 28th January at Canonbury, London. Until the end, though frail in body, he retained his faculties and interest in life, and his last paper on a bone of a pelican from the Yorkshire peat appeared in *The Naturalist* so recently as June, 1928.

Newton was born at Islington in May, 1840, and after leaving school received some manual training, which stood him in good stead in his palaeontological work of later years. He attended Huxley's lectures at the Royal School of Mines in Jermyn Street, and in 1865 became assistant to Huxley, who was at that time Naturalist to the Geological Survey. He soon displayed originality and capacity for research, and throughout the whole of his official career he accomplished much more than his routine duties and made many important contributions to palaeontology. His earliest original observations were on the structure of certain bituminous coals, and like all English geologists of his and later generations he published his first paper in the Geological Magazine. This was in 1875, when he described the masses of spores in "Tasmanite" and other bituminous coals.

After Huxley's retirement from the Survey, Newton still remained as assistant palaeontologist, and in 1882, after Robert Etheridge's removal to the British Museum, he was appointed palæontologist as colleague of George Sharman. His chief official duty was then the naming of fossils collected by the surveyors and the preparation of lists to accompany the descriptions of the maps. He dealt with all groups and wrote occasional notes on varied collections, but his chief interest was in the fossil vertebrates, and most of his original contributions to science related to these.

Newton began his researches on fossil vertebrates with the fishes of the English Chalk and other Cretaceous formations, and summarized his results in 1878 in the second edition of Dixon's *Geology and Fossils of Sussex*, and in his Survey memoir on *The Chimaeroid Fishes of the British Cretaceous Rocks*. Henceforth, he took most interest in the fragments of vertebrates found in the Pleistocene and Pliocene formations of this country, and he made valuable contributions to knowledge in his Survey memoirs on *The Vertebrata of the Forest Bed Series of Norfolk and Suffolk* (1882) and *The Vertebrata of the Pliocene Deposits of Britain* (1891), and in subsequent papers, communicated chiefly to the Geological Society, on vertebrate fossils from various caves, rock fissures, and river deposits. Among these papers may be specially mentioned one on a human skull and associated remains from a Pleistocene deposit at Galley Hill, Kent, which was published by the Geological Society in 1895, and led to an interminable controversy.

Newton's most fundamental contributions to science, however, were made in three memoirs, published in the *Philosophical Transactions* of the Royal Society. In 1887 he gave the first satisfactory description of the brain of a pterodactyl, based on a specimen which he had obtained from the Upper Lias of Whitby. In 1893 and 1894 he described a series of reptiles from the Permo-Triassic sandstones of Elgin, Scotland, revealing for the first time in Europe genera related to the primitive reptiles already known in the Karroo formation of South Africa. By a most ingenious method of taking impressions from hollows left by the decay of the bones once buried in the sandstones, he reconstructed various parts of the skulls and skeletons, and added greatly to our knowledge of the groups they represented.

While engaged in his official duties and research, Newton found time to take an active part in the work of the London scientific societies, and he was a familiar figure at the meetings. At various times he was a member of Council of the Geological Society and Geologists' Association, and of the Publication and Finance Committees of the Zoological Society. He was elected a Fellow of the Royal Society in 1893, and received the Lyell Medal from the Geological Society in the same year. He was President of the Geologists' Association in 1896–8, and President of the Palaeontographical Society from 1921 to 1928. He ceased regular association with his scientific colleagues only when the feebleness of advancing years prevented his going far from home, and his absence left a regretted blank.

CORRESPONDENCE.

A QUESTION OF NOMENCLATURE.

Sir,—For facility of description and discussion, a name is needed for the ancient Volcanic Series of the country between the Menai Strait and Snowdonia, a region known for centuries as " Arvon " because it faces Anglesey (Von = Mon = Anglesey). The series comprises the well-known rhyolite of Llyn Padarn, the rhyolite between Bangor and Carnarvon, and the pyroclastic rocks of Bangor itself. Moreover, in the course of mapping, I have found that it is a good deal more extensive, various members occurring at places where they have not hitherto been recognized. The formation is of great importance in the early volcanic history of Britain.

But, as is well-known, its age has been a matter of serious controversy; Geikie, Blake, and others holding it to be Lower Cambrian; Hughes, Bonney, and others holding it to be Pre-Cambrian. My own duty in the matter is to reserve judgment until my mapping is completed, as several perplexities remain. Perhaps, however, I may venture so far as to say that a Pre-Cambrian age now seems highly probable. Nevertheless, in view of possible error, the name adopted should be free from chronological assumptions. Yet even if the series be Pre-Cambrian, that term alone is insufficient, since it is certainly (Greenly, *Q.J.G.S.*, 1923, pp. 334–5) far later than the Mona Complex. We need some such term as Uriconian or Pebidian, though it may be long before we can correlate with those formations.

The familiar local place-names do not lend themselves to our purpose. "Bangorian" is ponderous; "Dinorwiggian" tends to evoke a smile. "Segontian," suggested to me by Mr. Cantrill, is euphonious, and appropriate because Segontium was the Roman Castrum-in-Arvon (= Car-n-arvon). True: an objection can be raised that Segontium itself stands on Ordovician rocks. But Professor Lloyd, the historian of Wales, tells me that the Roman fort must have been named after the river, and the river does traverse several miles of the rocks we are considering.

But the ideal name is, obviously, "Arvonian". Hicks, indeed, when introducing that term (*Q.J.G.S.*, 1879, p. 287) did actually apply it to this very series. Unfortunately, he also applied it to certain rocks at St. Davids which turned out not to be a "formation" at all, and as Mr. Green remarks, "the term was dropped by general consent." It seems hard, however, that by reason of an error of half-a-century ago which, after all, was an error in South Wales, not in North Wales, we of to-day should be debarred from the use of so felicitous a term.

I hesitate, nevertheless, to revive it without having ascertained that it will command the general assent of workers on the ancient rocks of Britain. Accordingly, the purpose of this letter is to elicit comment. Not that complete unanimity is necessary. "Ordovician," for example, did not command unanimity for a good many years. But I do wish to know whether there would be serious and widespread disapproval. So I propose to act as follows.

(1) In the event of serious disapprobation, I will fall back upon "Segontian".

(2) Unless someone devise some term which is better than either.

(3) If serious disapproval be not manifested, then I will adopt "Arvonian". And I hope that such will be the case.

I will ask all those who have any decided feeling on the matter, on one side or the other, to make it known, and to do so within a few weeks at latest, so that I may be able, in some two or three months, to arrive at a decision which there will be no need to reverse.

EDWARD GREENLY.

[The Editor regrets that owing to the very large number of original papers now in hand, he cannot undertake to publish correspondence on this subject: letters should be sent to Dr. Greenly, at Aethwy Ridge, Bangor, Carnarvonshire.]